Vol. XVI
No. 4

PSYCHOLOGICAL REVIEW PUBLICATIONS

July, 1914
Whole No. 70

THE

Psychological Monographs

STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF THE UNIVERSITY OF CHICAGO

An Experimental and Introspective Study of the Human Learning Process in the Maze

---

BY

FLEMING ALLEN CLAY PERRIN, Ph.D.

Instructor in Psychology, The University of Pittsburgh

PSYCHOLOGICAL REVIEW COMPANY

PRINCETON, N. J.

AND LANCASTER, PA.

AGENTS: G. E. STECHERT & CO., LONDON (2 Star Yard, Carey St., W. C.); LEIPZIG (Koenigstr., 37); PARIS (16 rue de Condé)


PRINCETON
UNIVERSITY
PRESS

ACKNOWLEDGMENTS

My sincere thanks are due to Professor James Rowland Angell and to Dr. Harvey A. Carr for their advice and suggestions during the course of the experimentation, and to the twelve subjects who gave both time and patience to the learning of the mazes.

CONTENTS

I. INTRODUCTION

The incentive to the experimentation reported in this paper was an interest in the problem of correlating human and animal learning behavior. The most obvious and direct method of approaching such a correlation is by way of an objective test that will elicit similar reactions from the animal and the human being. The maze was suggested to me as the most convenient laboratory device for that purpose. Whatever may be the merits of the maze test, it at least affords a basis for a comparison of the activities of an inclusive range of animal types.

The dearth of published accounts dealing with the normal human adult reactions in the maze led me to believe that the investigations should be initiated in that practically untried field. Such a series of tests promised, in the first place, a set of learning curves that would invite speculative comparison with the animal maze curves obtained by Watson, Carr, and others. In the second place, the project suggested the possibility of interesting introspective results. The question of whether or no the subjective phases could be utilized for immediate purposes of correlation was thought to be entirely beside the point. I assumed that the objective results of a learning process which involved conscious functions could be explained adequately only in terms of those functions. Accordingly, the introspective reports have received the larger share of the emphasis, in conducting the experiments as well as in formulating the results.

The present investigation purports to be nothing more than a preliminary study of the general problem. It was begun in the hope that it would include an attempt at the correlation mentioned; it was finished after having submitted to laboratory test only the more obvious questions suggested by the title.

I have omitted the customary bibliography from this paper. The list of references bearing directly upon the subject is exceedingly meagre, and an attempt to give a complete bibliography of the learning process would scarcely be warranted in an account

of a very limited investigation of one phase of the topic. An excellent list is given by Ellison [Ped. Sem., 1909], and a more extensive one is furnished by the Clark University, "Bibliographies of Experimental Pedagogy".

II. EXPERIMENTAL SECTION

The experiments which furnished the material for this discussion were begun in the fall of 1909 and were continued through three academic years. All of the work was done in the psychological laboratory at the University of Chicago, with the exception of Experiment II. The mazes employed in the laboratory were designed by the experimenter, and were constructed by the technician of the department. Two types of maze were used—the pencil maze, and one through which the subject walked. A number of different pencil mazes were employed, which are described in the respective accounts of the different experiments.

The subjects were all adults, either graduate students or members of the faculty in the departments of psychology and philosophy. Throughout all the experiments they were blindfolded while learning the different mazes. The learning was by trials, and after each trial were recorded, (1), time, taken by the stop-watch, (2), errors, (3), description of behavior, (4), detailed introspection. The subject was each time asked to give as complete an introspection as possible, and was then quizzed by the experimenter.

The following served as subjects: Professor J. R. Angell, Dr. J. W. Hayes, Dr. Mary H. S. Hayes, Dr. Grace M. Fernald, Dr. Mabel R. Fernald, Dr. Ethel M. Chamberlain Porter, Miss Sarah M. Ritter, Dr. H. F. Adams, Dr. W. S. Hunter, Mr. R. B. Owen, Mr. E. W. Burgess, Miss Carrie Nicholson.

The investigations comprised a series of four principal experiments, which are described below under the headings of Experiments I, II, III, IV. In connection with the first a series of supplementary tests was conducted which are referred to as Tests 1, 2, 3, etc., and which are described at the close of our account of Experiment I.

A. EXPERIMENT I

The maze used in this experiment is referred to as the "Normal" maze, for two reasons: (1), it is as exact a duplicate of the modified Hampton Court maze used by Watson and Carr with the white rat as practical convenience permitted; (2), it was the pencil maze employed in our endeavor to ascertain the general course of the learning process. All of the other mazes used, with the exception of the one described in Experiment II, were designed with reference to a study of special aspects of the learning process.

1. Apparatus and Method

(*a*) *Description of maze:* The maze consisted of a sequence of paths and cul-de-sacs in the form of grooves cut through a board 5/16 inch thick. The grooves were 1/2 inch in width, and the board was 16 by 24 inches in size. A diagram of the maze pattern, in correct proportions, is given [Fig. 1.] on the opposite page, together with the numbers and letters used in our description to designate the various paths.

The maze rested upon a base of plate glass, and between the two a sheet of paper was placed, so that as the subject traced through the path with a pencil, a permanent graph was preserved on the paper of all his movements in the maze. The glass in turn rested upon a heavy table, upon which the whole apparatus was securely clamped, in a fixed position, marked out on the table. The subject sat in a straight-backed, comfortable chair during the trials, at a distance from the maze best suited to his ease and convenience. The starting box of the maze was directly in front of him, at a position approximately even with the mid-line of his body; the side BC of the maze was to his right. The position of the chair with reference to the maze and table remained constant throughout the experiment, and the position of the whole apparatus in the experimental room remained the same.

(*b*) *Method:* Each subject made one trial a day, at a fixed time, for six days in the week. During the progress of the ex-

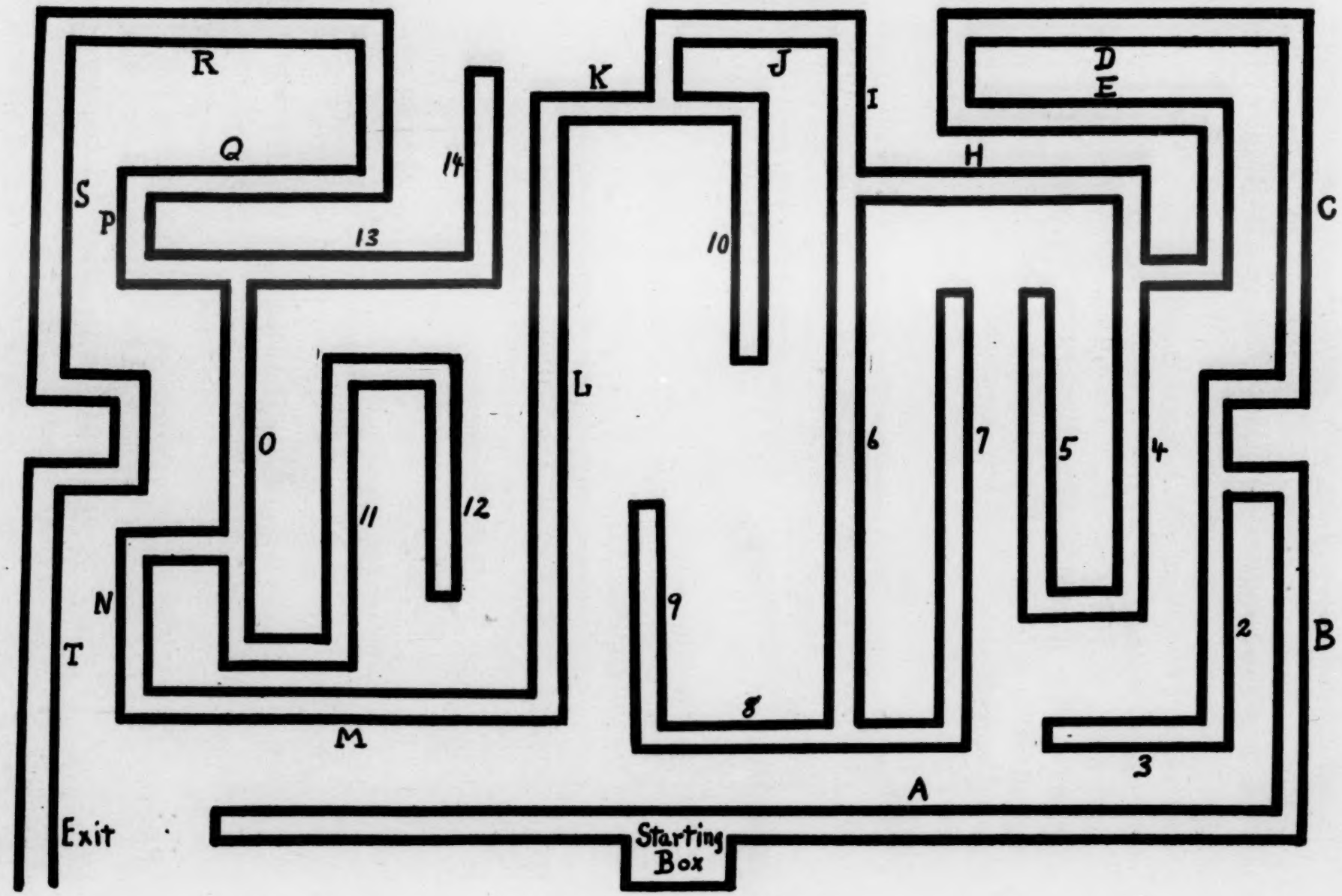

FIGURE 1. Normal Maze.

perimentation, various exigencies made a rigid adherence to the time schedule impossible. When these deviations from the routine procedure were responsible for discernible modifications in the learning process, the fact is noted in the discussion. With the exception of one subject only, not more than one trial per day was permitted each subject.

For each trial, the subject came into the experimenter's room, where a screen prevented him from seeing the apparatus. He was seated, and blindfolded with a pad of black China silk stuffed with cotton, that effectually excluded all light. He was then led around the screen, seated at the table in front of the maze, and given a pencil, the point of which was placed in the starting box by the experimenter.

The instructions and directions given each subject at the beginning of the first trial, to be observed for each trial, were as follows: (1) Hold the pencil in a position as nearly vertical as comfort will permit, and at the spoken signal, "start", endeavor to find the exit by tracing, keeping the pencil-point in contact with the floor of the maze (i.e., the paper) until the trial is completed. (2) Hold the pencil in any natural way desirable, but do not let the hand or arm come in contact with the maze. (3) Absolute freedom is allowed as regards retracing, stopping in the maze in order to think, or to relieve fatigue. (4) Time is to be counted from the starting signal until the exit is reached. "Time out" will not be granted except for unforeseen exigencies. All errors are to be recorded. An error is defined as a *false turn:* e.g., turning into a cul-de-sac from the true path, making any turns inside the cul-de-sac except those involved in retracing towards the true path, making turns on the true path in a direction away from the exit. (The subject of course learned to discriminate the true path from the false only as he made progress in the learning.) (5) Employ any learning technique available or desirable: that is, freedom is permitted each subject as regards thought processes or distribution of attention. Speaking aloud during the trial is permitted, but the experimenter will make no comment during the trial. In general, each subject is to employ any technique consistent with the directions

given. (6) Subjects are not to think of the maze, or of learning methods, or to communicate with each other on the subject between trials. (7) The maze will be considered learned when the subject is able to trace the shortest route, provided there is more than one, without error, for five trials in succession.

2. Results obtained from Experiment I—analysis of the learning process

(*a*) *General account of the objective behavior of the subjects in the maze, and of the nature of the learning process:* It was obvious from the introspective reports of the first trial that the learning process was to be largely a conscious one. Each subject, without raising the question of the possibility of any other method, set about to develop an ideational control over the maze. Motor habits played an increasingly important rôle during the succeeding trials; and various subjects reported during the course of the experiment, that the pattern of certain segments, which they had learned to run without error, had never been completely apprehended. But with these exceptions, the ability to run the maze, with a decreasing number of errors, developed with the ability to image the path, and to describe it verbally or graphically.

As the blindfolded subject was engaged in the active task of exploring the maze with the pencil, he was the recipient of a definite sequence of kinaesthetic sensations, due to arm movement and strain, and cutaneous sensations, as the pencil tip was pushed along the side of the pathway, or was moved without contact with the sides, or was suddenly brought into contact with the end of a passage and stopped. This immediate sensory experience, however, was reacted upon in a perceptual way. The subject's attention was, not on kinaesthetic and cutaneous sensations as such, but upon pathways running in various directions, and the turns and branches of the pathways.

The subject's reaction was not merely a perceptual one. The experience of paths and turns was immediately translated into image forms, of a nature and to an extent varying with the individual. Verbal processes were elicited, by way of description

and comment. The subject set himself more or less actively to the task of discriminating true paths from the false, of retaining, out of the confusion of experiences, the memory of the true path; of organizing his knowledge gained from each trial in such a way that it could be adequately applied to the succeeding trial, for the purpose of effective control over the task he had undertaken.

(*b*) *Summarized characterization of behavior:* The following brief description of the objective behavior throughout the experment applies in general to each subject. The first two or three trials consisted in a seemingly aimless trying-out of paths that offered themselves, a performance that strongly suggested the efforts of a newly-caught animal to escape from a pen. After this period, the procedure was as follows: (a), a tendency to work over into the general course of the true path. In doing so, each subject entered various cul-de-sacs, to a decreasing extent as he made progress. He entered the cul-de-sacs directly by turning off the true path, evidently not being aware of the mistake until he reached the blind end. The activity that followed in getting out of the cul-de-sac was very similar to that observed in the first few trials. It did not cease by any means when the true path was reached. (b) There was a very general tendency for the subject to enter the same cul-de-sac in this manner for several trials in succession, to drop it for a number of ensuing trials, and then to fall into it again for a time. (c) Most of the subjects, especially in the first half-dozen trials, would go repeatedly to the end of such a long passage, as S for instance, mistake it for the blind ending of a cul-de-sac, and retrace. (d) The subjects early learned to stick to one side of the path in certain regions, for the purpose of avoiding dangerous places on the other side, or because they had learned that the first turn on the side followed was the correct turn in the path. (e) A general tendency was observed to increase the speed of the pencil movement, (1), in familiar and safe segments of the path; (2), in trial and error attempts to escape from cul-de-sacs, or at any time when the subject became hopelessly confused—not necessarily in cul-de-sacs.

The chief observable difference in the behavior of the subjects was in the matter of speed. E. C. P. and H. F. A. made the quickest movements; J. J. T. and G. M. F. moved the pencil very slowly. The other subjects in this respect ranged between these two extremes, each represented by two subjects. Each subject established the pace in the first trial that was consistently to characterize his behavior throughout the trials.

(c) *Summarized consensus of introspections:* A brief general characterization of the subjective aspects of the learning process, based on unanimous testimony given by the subjects, will serve to introduce the more detailed individual introspective reports. They all state that the maze learning process took the form of discriminating and remembering a definite sequence of turns and paths from the confusion of experiences that characterized the first trials. Different turns and paths as they become learned acquired familiar cues, due to: (a), the feeling of arm position, as being extended towards the left part of the maze, the upper part, etc.; (b), kinaesthetic feelings of the length and direction of arm movement in traversing any one path; (c), a projected tactual feeling at the end of the pencil, as it turned corners and followed the paths. This element was slightly emphasized except in the case of J. W. H.; (d), the image schema of the maze, as checked up by these various sense factors.

The difficulty of organizing an adequate control knowledge of the true path may be ascribed to two causes: (a), the great initial difficulty, that decreased as the subject developed his control, was a matter of memory. At any given time during a trial, the subject could remember fairly well the last consecutive 2-5 turns and paths. But it was very hard to keep in mind the memory of the turns traversed earlier. (b) The second great difficulty was that of discrimination. The subject would proceed on what he was more or less sure was the true path, and would suddenly find himself at the blind ending of a cul-de-sac. He had no way of telling which one of the half dozen immediately preceding turns had led him off the true path, even if he were able to remember them.

After the first half dozen trials, the difficulties became located at two or three definite regions in the maze. The subjects had learned that certain segments were relatively free from dangerous situations, (e.g., A-F and P-T). The running of these segments became habitual, in the sense that while traversing them, the subject's attention was anticipatory, concerned with difficulties ahead. Motor habit, and the mechanical construction of the maze itself, were in this manner important factors in the learning process. The habit element assumed an increasingly important rôle as the trials were continued.

(*d*) *Summarized reports of the individual subjects as regards the nature of the learning process:* In the following reports, the data bearing upon the learning method have been abstracted from the complete introspections.

(1) Subject H. F. A. At the completion of the first trial, he had a scheme of the path in mind that he represented by the drawing [Fig. 2]. He adopted in this trial, and followed consistently throughout the experiment, a working method which he describes as that of "conscious trial and error". Each day he attempted to work over in the general direction he knew the path to extend, with the aid of the memory of such specific segments as he could retain. He would follow any given path to the end, the "bump". There he might or might not get a cue for the proper turn, a kinaesthetic memory experience. If he got it, and it turned out to be the correct one, well and good; if not, he would work around in haphazard fashion, and eventually recover his bearings. He made no special attempt to reason out situations, or to formulate plans or theories. He did consciously attempt to discriminate and remember. He thinks he learned the maze, "as a rat learns it—assuming that it is conscious—by a trial and error method, and an associative memory control." Furthermore, he employed the same cues that a rat presumably utilizes—kinaesthetic and tactual experiences.

FIGURE 2. Drawing of Normal Maze, end of first trial, H.F.A.

(2) Subject M. R. F. She purposely adopted on the start a trial and error method, but with this, in the first trial, and throughout the ensuing trials, she assumed a decidedly rational, thinking attitude towards her task. She conceived the idea, (I),[1] of exploring one side at a time, but it did not prove to be a sucecssful procedure. The results of trials (I-IV) were general orientation—the general spacial relations were learned first. Like H. F. A. (and other subjects) she was alertly on the lookout for familiar passages, but she made more elaborate anticipatory judgments and plans—"The next time I reach this corner, I am going to turn north and see what happens." At (IV) she started out with the general working idea to eliminate useless movements. She planned, for instance, to avoid a "bad place" on the right by trying to find a new path around it. She thinks about the maze as she learns, in verbal terms, sometimes spoken aloud, such as: "Never went up here so far before; yes, this is O. K.; guess I'll try this path to-day." By trial (XVI) she believed there were four different paths in the maze; just how much is common route, she doesn't know. She thinks possibly the maze is being altered as she learns. (The experimenter was extremely careful in the preliminary directions to state that there might or might not be more than one true path. He made no mention of possible alterations during the learning.) The whole process was largely a series of discoveries and guesses. She used conscious exploration to check up her theories, but exploration almost inevitably resulted in getting hopelessly lost. In (XXII) she found herself in a familiar cul-de-sac, 6-9, and recognized it, but was sure she escaped from it by a new path. By (XXVIII) she is firmly convinced that there is more than one path—stated that while she used to come down a long path in the middle of the maze, (L), for the last three or four trials she has been entering it from the right, at a place much lower down than usual—that is, the path is perceptibly shorter than it formerly was. Therefore, she concluded, there are two ways of getting into it, and therefore two paths in the right part of the maze. She hit upon the idea of learning one of the paths in

[1] The Roman numerals in parentheses refer to the number of the trials.

the maze, and letting the others go. At (XXXIII) she has the situation under control—that is, she can go through one of her paths without error. At the conclusion of the experiment, she had not discovered the the nature of the other paths; but technically the maze was learned.

The reports of this subject present a distinct contrast to those of H. F. A. Her attitude was consistently a more rational one. She did more thinking about the problem. But she reports that practically her learning was by the method of trial and error, that the discoveries she made which were of vital importance were more or less accidently hit upon.

(3) Subject E. C. P. This subject was our most consistent and exclusive visualizer, and her overt aim from the start was to build up a visual image of the maze path for the purpose of control. To the extent that she accomplished this, she made progress in the learning. In (I) she became conscious that she was in the right side of the maze, and started to work over to the left. Her whole subjective process went on in terms of building up and reconstructing this visual pattern. The general shape was developed first, i.e., (IV) "The path is of the form of the capital M." Her attitude was consistently one of active attention, discrimination, and memorizing. At times she attempted to follow tentatively a few working ideas—like M. R. F., she attempted to "dodge" the cul-de-sac region on the right by trying to work around it. But she does not report much systematic thinking or planning. Her procedure was to go ahead, learn what she could by experience, and construct out of it as best she was able her control image. She aimed to make her actual movements as rapid as possible, to go cautiously in certain regions, but to depend upon excess motor activity as the best method of procedure. By (XXIII) she had a schematic visual image of the path, accurate as far as the correct sequence of turns is concerned. The errors she made after this trial were due, she thinks, to careless attention.

This subject's account offers points of similarity to the reports of both H. F. A. and M. R. F., but it seems to represent a third distinct type of method. Without the excess play of ideas of

M. R. F., she had that subject's attitude of active, concentrated attention and mental effort. In this respect she was a pronounced contrast to H. F. A., who from a comparison of the respective reports, seemed mentally more careless. Like him, however, she adopted a method characterized by its emphasis upon excess random activity, as the result of which the correct paths could be selected and retained.

(4) Subject M. H. S. H. The general working method of this subject is rather difficult to characterize. A rather extensive rational procedure that she indulged in, in connection with learning to avoid a certain cul-de-sac, is described in an ensuing section of the account of this experiment. Her testimony is to the effect that she proceded as a rule cautiously, with her attention alert for kinaesthetic cues. Her aim was to build up a control, in terms of a sequence of anticipatory motor images. This called for a rather active process of attending closely to kinaesthetic experiences, selecting out of them the ones concerned with sections of the true path, and organizing these into an adequate idea of the route. She indulged freely in verbal expressions, spoken aloud during the trial, but they were predominately by way of comment and exclamation, rather than description or systematic thinking.

(5) Subject J. W. H. The reports of J. W. H. as to method are very similar to those of E. C. P. They differ radically in one respect. This subject tended to rely upon motor habits as soon as they appeared, and let consciousness concern itself with other parts of the maze, or with extraneous matters, while E. C. P. put less emphasis upon the habit element than any other subject. She seemed to attend consistently to her visual scheme of the maze while traversing it.

(6) Subject G. M. F. This subject differed from all the others in developing an auditory-verbal formula as a control of the maze. In the actual constructing of this set of verbal directions however, she used the type of kinaesthetic processes and imagery described by M. H. S. H., and employed them in much the same way. That is, she did her thinking in these terms, rather than in verbal terms. She was still more conservative than the

subject just referred to in the matter of random exploration. Subject G. M. F. made very slow movements in the maze. She engaged quite consciously in what she called "wondering" or guessing, but made no great effort to reason out situations. She does not report attempts to try out different schemes, such as sticking to one side, altering speed, etc. In one or two instances, she undertook a systematic exploration of certain segments of the maze, but did not place much emphasis upon the value of such a procedure. She gave each trial an attitude of close attention; but her mental activity seemed for the most part to be concerned with discriminating kinaesthetic experiences, translating them into her verbal formula, and memorizing that formula.

(7) Subject J. J. T. The introspections of this subject indicate more fluctuations and irregularities than those of any other learner. For the most part she put her active attention upon her task, but in several reports "relaxed attention" is the predominant theme. Like the other subjects she was on the lookout for familiar cues, and in seeking them she put the emphasis upon the "long sweeps." She made no special effort at thinking out situations. She did at times attempt rather systematic exploration. But several times she indulged in what she called "willful and malicious" exploration: that is, with no special motive in view except curiosity. All of her explorations she reported futile. She did some theorizing, or rather, guessing—e.g., she conceived at various times that there was more than one path in the maze. But like G. M. F., she did not develop her guesses into theories, and systematically attempt to substantiate them.

(*e*) *General comments on the different reports as to method:* It is evident that the various subjects took different attitudes towards their problem. By attitude we mean simply the learning method the subject attempted to apply. Two opposed attitudes can be fairly well defined, in the light of the data given. One represents a more active, volitional attempt at thinking than does the other. The data also suggest another possible basis for a distinction of attitudes. Eliminating the matter of the amount of thinking, some of the subjects seemed to concentrate their attention upon the problem more than did others. On the basis of

the first distinction we contrasted H. F. A. and M. R. F.; on the grounds of the second, E. C. P. and J. J. T. It is to be emphasized that these distinctions are decidedly relative ones, but the introspective records seem to justify a tentative classification on these bases.

Assuming that there are differences in attitude, in the way the term is defined above, the question is strongly suggested, do these attitudes represent actual psychological differences in method? Each subject effected a process of mental organization of experiences that functioned in his successful learning of the maze. Was the nature of this organization and application of experiences essentially the same for all the subjects? It is significant that all of them reported that they had to resort to a trial and error method sooner or later; but it is quite possible that they underestimated the importance of the rationalizing they indulged in. It is conceivable that the adult human mind functions in such a way that no other type of mental behavior is possible for this special learning process. But it is likewise possible that the mind is of such complexity that it may approach this type of problem in a variety of ways. The question was thought important enough to be made the object of a special investigation, which is described in Experiment III.

3. The functioning of some of the specific activities involved in the learning process

(*a*) *Imagery, and sensory processes:* No special reference was made, in the account of method, to the various types of imagery employed by the various subjects. This was made, however, a special topic of study, the motive being to determine if possible the relative efficacy of the different types employed, provided there were indications that any one type or combination showed itself to be of superior value in the learning activity. It is possible that in the instances where any one subject employed a complex of different kinds of imagery, some of them were of functional importance, and some of them merely accessory. The question of how the imagery was used, was deemed to be of primary importance.

In our attempt to determine the imagery employed, we availed ourselves of the evidence presented by three lines of data: (a) detailed introspection on this subject was called for throughout the experiment; (b) an attempt was made to check this up by some objective tests, after the experiment was concluded; (c) one of the subjects was at the time of the investigation engaged in research on the problem of imagery diagnosis, in which she employed many of the introspectors who learned the mazes. Our records were checked up with the analysis she had made at the time.[2]

We had represented among our subjects a rather inclusive variety of image processes, complicated in all instances with sensory activities. The experience of tracing the path through a pencil maze necessarily elicits kinaesthetic and tactual factors. It was not to our purpose in every instance to distinguish sharply between the two factors, but we attempted to do so when there appeared any functional reason for the analysis.

(1) Characterization of the subjects with reference to imaginal and sensory elements employed: (i) J. W. H. Quite sensitive to tactual processes in the maze. Utilized a strong sense of egocentric projection—the tactual feeling projected to the end of the pencil. Less conscious of kinaesthetic factors. On the basis of these experiences he developed visual imagery for certain segments of the maze, and employed the tactual-visual complex as his conscious control.

(ii) M. H. S. H. A very pronounced and almost exclusive consciousness of kinaesthetic processes. While actually engaged in going through the maze her active attention was upon, (a), the motor sensations from the hand and arm, and to a less extent, from the body; (b), the unambiguous anticipatory imagery of the turn-to-come. We were not interested to determine whether this was purely imaginal or in part sensory in its make-up. It was a definite kinaesthetic anticipation of the segments of the path immediately in front of her, including one or at most two turns, of a more inclusive segment of the maze. Her idea of the

[2] M. R. Fernald: The Diagnosis of Mental Imagery, Psychol. Rev., Monog., Suppl., 1912, vol. XIV, No. 1.

maze was built up in terms of this kinaesthetic experience. Her learning, in its subjective aspect, involved the process of discriminating the sensory experiences concerned with the true path, retaining them, and applying them in the form of anticipatory images in succeeding trials.

(iii) G. M. F. was like M. H. S. H. in having strong motor imagery, and in being primarily conscious of kinaesthetic sensory experiences while running the maze. She was peculiar among all the subjects in that she built up, as she learned, a specific auditory-verbal formula, which, as checked up by the motor imagery, served for a guide. She testified that she could not dispense with this formula, even during the last trials.

(iv) M. R. F. employed a mixture of "vague, fleeting visual, scattered verbal, and indefinite motor imagery." At times one element would temporarily predominate. As a rule she was unable to determine the relative importance or extent of the different components in the complex.

(v) E. C. P. was a very definite and practically exclusive visualizer. She built up a clear-cut visual image of the maze, which she describes as schematic, in the sense that it was composed of "lines," rather than being an image of an actual wood maze, of any certain color, etc. Like G. M. F., she used her image as a guide for every trial, and ventured the opinion towards the close of the trials that she could never run through the maze without it.

(vi) J. J. T. found it difficult to introspect on her imagery. She was conscious of kinaesthetic complexes, but had no definite motor imagery, and little or no visual. She does not think she employs much imagery—what she knows about the mazes she simply "knows."

(vii) H. F. A. employed a kinaesthetic complex which he did not try to analyze into its imaginal and sensory components—i.e., his anticipations of turns were closely involved with the turns themselves. With this he used some verbal material. No visual or tactual.

(2) Some data on how the imagery functioned: The type or combination each individual employed was used throughout the

experiment, and was the same that the subjects reported in their statements made during the investigations of M. R. F., referred to above. There were no radical attempts to shift from one type of process to another. Each subject reported fluctuations in the amount used through the trials. In general, when the learner increased his effort to concentrate, or to study out situations, he reports an accentuation of image activities. To the extent that the learner relied upon the habit factor, the imagery was lost.

The image activities were either retrospective or anticipatory. One aspect of the learning process was the retention of the segments just traversed; the other was the application of this remembered experience in a succeeding trial by way of an anticipation of the turn or turns to come by means of which the subject was successful in making them correctly.

There were some differences reported as to the amount of path actually anticipated. E. C. P. would develop her image of the whole route, or as much of it as she knew, before leaving the starting box, after the signal to begin had been given. The two or three turns immediately in front of her would be more vividly expressed, however, as she went through the maze, while the "trail" behind would be practically ignored. M. H. S. H. would get her image of the turn-to-come when half way or two thirds of the way down the preceding path. The same type of image employed by G. M. F. would usually include several anticipated turns; but it was used in connection with her verbal formula, and included only certain segments of the maze. She elaborated her formula as she had actual use for each step in it when going through the path. H. F. A. reported that his cues for the turns came as a rule after the "bump," when the end of the path was reached. The other subjects gave more varying testimony as to the extent of path that was anticipated.

It is rather difficult to gauge the importance of the motor element. One would assume after reading the reports that the kinaesthetic processes played an important rôle with all the subjects, that the cue that was focal with M. H. S. H. functioned to some extent with all. This would of course imply a persistent

relationship between the kinaesthetic processes and motor habit. The definite motor image cue which this subject got some distance ahead of the actual turn was probably the same that J. J. T. and H. F. A. acted on in their controls; although in their cases it was not acted on as such, and it was closely identified with the actual act of turning. The tendency for the whole kinaesthesis to become habitual probably accounts for the phenomena of habit reported almost universally in the latter part of the learning. The introspections seemed to indicate that the kinaesthetic process behaved differently with different subjects, and we have some reason to believe that it actually functioned to a different relative degree with different subjects. It is interesting to note that E. C. P. consistently reported that she did not consciously utilize kinaesthetic processes as a guide at all. She was unique among the subjects in this respect. It is also significant that she also reported little or no automatism or habit, again differing from the other subjects. E. C. P., it is to be remembered, was our most consistent visualizer.

In general, as far as our introspective data are valid, the different image processes, when represented in one individual, reinforced each other. It is interesting to note that while G. M. F. reported that her verbal formula was her immediate control, it is hardly sufficiently explicit to guide a subject, unfamiliar with the maze, through its paths. It reads, "Along in this alley—around corner—here—straight up, going to turn to left—now I go down—back to right—now here I must be careful and stick to upper side of alley," etc. This is for the region A-H. Evidently this set of directions alone could scarcely suffice for safe passage through the maze. The inference is that it was probably reinforced by motor cues, feelings of familiarity, etc.

In one or two cases we found instances of an image conflict. G. M. F. reports such a case where the formula told her to go one way, while a motor image directed her into an opposite path. The verbal cue turned out to be correct. M. H. S. H. in two instances reported a conflict of motor images. This was after she had just learned to avoid a cul-de-sac, and one tendency represented the habit effect.

(3) The question of the relative efficacy of the different types of imagery employed: It was impossible, after a comparison of the objective records and the introspections, to make any positive correlations between efficiency and the type of imagery used. In the first place, it is obvious that too many complications enter into the learning. Two of the best learners, E. C. P. and H. F. A., used very divergent image processes. Two of the subjects who employed similar image controls, H. F. A. and M. H. S. H., have extremely opposed objective records.

After the maze was once learned, any one type of control was as efficient as any other, as far as the criterion established for this experiment was concerned. Evidently, the relative superiority of any one type of thought process, if such existed, must have asserted itself during the earlier part of the learning.

There is some evidence to indicate that those with predominant motor imagery tended to establish stronger motor habits than the others. M. H. S. H., in the distraction tests, to which reference is made later, was exceedingly successful in going through the maze when her attention was mainly concerned with other things. E. P. C. failed in the same test. But this does not by any means imply that a strong tendency towards the establishing of non-conscious habits is beneficial in learning a maze. Habits worked for harm as well as for good. In the case of M. H. S. H., a cul-de-sac became incorporated into the true path and was habitually run for a number of trials before the mistake was discovered, each time being responsible for a number of errors.

It may be that visual imagery is intrinsically better adapted to express spatial relations than kinaesthetic or verbal. It is more comprehensive—a verbal image must unroll itself in time, as must also kinaesthetic one, while the visual image is presented more instantaneously. E. C. P. anticipated more of the path before reaching it than did any other subject; H. F. A. did less than any other. Both had good records.

The conclusion was strongly suggested to the experimenter in the light of all the data at hand, that the learning depended upon the ability of the subject to organize the experience pre-

relationship between the kinaesthetic processes and motor habit. The definite motor image cue which this subject got some distance ahead of the actual turn was probably the same that J. J. T. and H. F. A. acted on in their controls; although in their cases it was not acted on as such, and it was closely identified with the actual act of turning. The tendency for the whole kinaesthesis to become habitual probably accounts for the phenomena of habit reported almost universally in the latter part of the learning. The introspections seemed to indicate that the kinaesthetic process behaved differently with different subjects, and we have some reason to believe that it actually functioned to a different relative degree with different subjects. It is interesting to note that E. C. P. consistently reported that she did not consciously utilize kinaesthetic processes as a guide at all. She was unique among the subjects in this respect. It is also significant that she also reported little or no automatism or habit, again differing from the other subjects. E. C. P., it is to be remembered, was our most consistent visualizer.

In general, as far as our introspective data are valid, the different image processes, when represented in one individual, reinforced each other. It is interesting to note that while G. M. F. reported that her verbal formula was her immediate control, it is hardly sufficiently explicit to guide a subject, unfamiliar with the maze, through its paths. It reads, "Along in this alley—around corner—here—straight up, going to turn to left—now I go down—back to right—now here I must be careful and stick to upper side of alley," etc. This is for the region A-H. Evidently this set of directions alone could scarcely suffice for safe passage through the maze. The inference is that it was probably reinforced by motor cues, feelings of familiarity, etc.

In one or two cases we found instances of an image conflict. G. M. F. reports such a case where the formula told her to go one way, while a motor image directed her into an opposite path. The verbal cue turned out to be correct. M. H. S. H. in two instances reported a conflict of motor images. This was after she had just learned to avoid a cul-de-sac, and one tendency represented the habit effect.

(3) The question of the relative efficacy of the different types of imagery employed: It was impossible, after a comparison of the objective records and the introspections, to make any positive correlations between efficiency and the type of imagery used. In the first place, it is obvious that too many complications enter into the learning. Two of the best learners, E. C. P. and H. F. A., used very divergent image processes. Two of the subjects who employed similar image controls, H. F. A. and M. H. S. H., have extremely opposed objective records.

After the maze was once learned, any one type of control was as efficient as any other, as far as the criterion established for this experiment was concerned. Evidently, the relative superiority of any one type of thought process, if such existed, must have asserted itself during the earlier part of the learning.

There is some evidence to indicate that those with predominant motor imagery tended to establish stronger motor habits than the others. M. H. S. H., in the distraction tests, to which reference is made later, was exceedingly successful in going through the maze when her attention was mainly concerned with other things. E. P. C. failed in the same test. But this does not by any means imply that a strong tendency towards the establishing of non-conscious habits is beneficial in learning a maze. Habits worked for harm as well as for good. In the case of M. H. S. H., a cul-de-sac became incorporated into the true path and was habitually run for a number of trials before the mistake was discovered, each time being responsible for a number of errors.

It may be that visual imagery is intrinsically better adapted to express spatial relations than kinaesthetic or verbal. It is more comprehensive—a verbal image must unroll itself in time, as must also kinaesthetic one, while the visual image is presented more instantaneously. E. C. P. anticipated more of the path before reaching it than did any other subject; H. F. A. did less than any other. Both had good records.

The conclusion was strongly suggested to the experimenter in the light of all the data at hand, that the learning depended upon the ability of the subject to organize the experience pre-

sented by the objective act of going through the various paths in the maze, rather than upon any type of imagery employed to retain these experiences. Several indications were found to the effect that different subjects *used* the same kind of imagery in different ways—e.g., M. H. S. H. and H. F. A. with motor imagery; G. M. F. and M. R. F. used verbal material in different ways.

(*b*) *Habit and Attention:* Very early in the series, in some instances in the first half-dozen trials, subjects began to report that certain segments of the maze were being run with the attention directed upon regions ahead, or upon foreign matters. This type of thing was the more emphasized as the trials continued, until various subjects, after the last few trials, reported that most of the maze was traversed with focal attention wholly concerned with other things.

This habit tendency developed in connection with two different kinds of situation in the maze: (1) certain segements, such as A-F, which had presented relatively few opportunities for error, never at any time became the object for much attention. Such regions early were reported as "almost automatic"—"attention concerned with the cul-de-sac ahead." Another type of thing occurred, of the same nature as far as the subjective aspect of it is concerned, of which the reports of M. H. S. H. afforded an excellent example. This subject incorporated the cul-de-sac path 6-8-9 into her true path without realizing what she had done. Ordinarily, the end of a blind passage afforded a sufficiently characteristic cue to inform any subject that he was in a cul-de-sac. In her case, however, the passage to the end and back was sensed merely as a turn in the true path, and as a result, this part of her path became habitual before she discovered her mistake. (2) In other instances, segments which were learned at considerable expense of attention and study eventually became habitual. The path F-K was the common instance of this.

The behavior of attention has already been referred to in our report of the image processes. It either, (1), kept pace with the actual activity in going through the maze, (2),

"lagged behind," or was retrospective, engaged in the attempt to retain the knowledge just acquired, or (3), was anticipatory. In a relative way, these three types of the play of attention made their appearance in the order named. Ordinarily, the progress of any trial, or the traversing of any one path, would elicit a back and forth play of attention between the region ahead and the "trail" behind, checked up by constant reference to the path the subject was actually engaged in making. This behavior is characteristic of all the subjects.

A rather surprising divergence of behavior in the matter of habit was in evidence. E. C. P. constantly testified that her visual scheme was her control, and that she employed it in her last trials as consciously as she did in the first. She was quite sure that she would never be able to dispense with it. M. R. F. also emphasized to a very small extent the phenomenon of unconscious running of segments of the maze. But this subject was engaged in an active series of studies throughout the learning, while E. C. P. was one of the first to build up an adequate idea of the true path. G. M. F. reported her verbal formula essential to the last.

In general, the appearance and predominance of the phenomenon of unconscious running seemed to be correlated with the relative reliance upon kinaesthetic factors, but J. W. H., who next to E. C. P. employed visual imagery, emphasized the habitual, unconscious elements more than any other subject. J. W. H., also, it is to be remembered, reported on the introspective side a minimum of kinaesthetic processes. He thought they were decidedly subordinate to tactual ones. But M. H. S. H. who relied so exclusively upon motor imagery, while she emphasized in her reports habitual running, maintained at the same time that it was a conscious performance. The appearance of habit is hardly to be ascribed to the number of times the maze was run. Those who did report it, testified to its appearance early in the series. Neither is it obviously correlated with speed, as a comparison of the different behaviors show E. C. P. and J. W. H. similar in this respect. It is not to be explained in terms of the amount of attention put into the learning as a whole.

J. J. T. and J. W. H., who occupy rather extreme positions in this respect, both report strongly the rôle of habit, in the sense of unconscious running.

The data, by way of summary, indicate that various subjects varied in their reliance upon the habit factor. In the instances of its extreme predominance, the subject could safely depend upon it to carry him through difficult regions of the maze while he was attending almost exclusively to extraneous affairs. In other cases, although habit facilitated the task of going through the maze, some attention to the difficulties in the route was necessary. Finally, two of the subjects reported that an amount of conscious attention was demanded in each trial, which did not seemingly diminish as the result of repetition.

(*c*) *Discrimination and Association, Memory and Recognition:* The processes involved in selecting segments of the maze which belonged to the true path out of the confusion of experiences which in the first trials presented themselves, and arranging them in the proper sequence, obviously constituted the main organization that the subject was called on to accomplish.

It has already been stated that certain passages early acquired familiar "tangs," due to their direction, extent, position, etc. Practically every passage had something analogous to a local sign, due to the quality, strength, and combination of kinaesthetic and cutaneous experiences occasioned by the act of traversing it and attending to it. But the subject had not only to attend, but to remember. At some given time in the early stage of the process, he would find himself stopped by a blind ending, say the termination of path 9. Assuming that at that moment he had rather definitely in mind, in some image form, the memory of 9-8-6-H-G-F just traversed, he would not necessarily have any cue as to which of the turns between these passages had led him off the true path and into the cul-de-sac. This was the type of difficulty reported universally. Add to this situation the fact that in the earlier trials the subject had in mind only a confused memory blur of the immediate past experiences, and the nature of the conscious side of the learning is easy to conceive.

The learner had two things to do in such an exigency. He

must in the first place escape *from* the situation. In many instances, especially in the earlier part of the learning, he deliberately resorted to a random trial and error method, letting any attempt to get a mental hold on the situation go where it would. But if he were to build up an adequate knowledge of the path, he must in addition learn how in the future to *avoid* such a situation.

It was then the concern of the subject to retrace, attend closely to his cues, and recognize the regained path as soon as possible. The chances are that in doing so he would go into 7 and back. Retracing from there (possibly reëntering 9) he would finally find 6, turn either into H or continue I, and make a number of ensuing turns before he found his bearings. Possibly in the next trial, in an attempt to escape from this region, he would turn down 4. At the end of 5 he would find himself, of course, worse off than he was in the previous trial.

There were two methods in evidence by which the subject learned to avoid this cul-de-sac 6-9. One was the actual process of learning the whole situation by repeated exploration. The other was the result of turning directly from H to I by accident, without at the time recognizing it as the correct thing to do, remembering this variation in the route, and afterwards ignoring passage 6. In this case the cul-de-sac was not learned at all. 6 was simply the opening from clear sailing into an unknown region of danger. This process of falling into difficulties and learning how to avoid the place on the true path that was the location of the difficulty, called for the discriminating, associating, memorizing processes. But it was obvious that two subjects could learn to avoid the same region by two methods, one of which called for a more active play of these processes than the other. Unfortunately, the subject, although he was aware of the two methods of escaping difficulties, could not choose between them. The second type of thing was invariably accidental, or due to causes which his introspection did not comprehend.

Thus while specific acts of memory and discrimination entered into the learning process, they did not constitute it. The background of preconceptions, the effect of habit, the play of

ideational activity, all entered into the mental organizing involved in these relatively simple forms of learning. The experimenter devised a series of extended tests designed to guage the ability of the different subjects in the matter of sensory discrimination and memory, under conditions as similar to those involved in Experiment I as possible. The results of these tests offered no basis for an explanation of the efficiency in the maze. As was noted above, E. C. P. was able to describe the path before it was technically learned. J. J. T., when the experiment was completed, was not able to describe accurately the sequence of turns. The relative lengths of paths were grossly distorted, even in regions where the path had been carefully worked out, by all the subjects.

(*d*) *Illusions:* It is convenient to make reference under a separate heading to the fact that the number and nature of the misconceptions the subject formed of the maze were startling. Lengths of paths were over- or underestimated frequently by one half. Certain areas of the maze were violently distorted as to position and relative size. The fact has already been referred to that one subject believed in the existence of four different paths in the maze. This may not properly be called an illusion, but we found it impossible to establish boundary lines between errors in sensory discrimination, illusions, and misconceptions due to guesses or theories.

That these illusions often played a definite rôle, generally to the detriment of the subject's control over the learning, is evident from the reports. Sometimes an immediate increase in time and errors resulted, but often the objective records show nothing of the misconception. H. F. A. (VII) ran up 15 errors due to the fact that he first noticed in this trial that M was a relatively long path: he had always considered it a short path, or rather, had not had his attention called to it at all. At this trial he entered it, was surprised at its length, concluded he was astray, and retraced, in an attempt to find the path he formerly took in getting from L to the left side of the maze. M. R. F.'s conception of the four paths resulted in needless exploration, and her error and time curves were correspondingly enlarged. J. J. T.

(X) found the relative proportions of the passages in the right side of the maze distorted, but since her idea of the sequence was unaltered, the discovery made no appreciable difference in her records. G. M. F. (VI) decided that there were two routes from the entrance to the exit. In this case, the judgment was the result of a careful exploration of the region. After the judgment was formed, however, it did not influence her error records, for she simply followed up whichever path she "happened to be on" in this region, and since there was only one, her record is clear.

As for the cause of these illusions, the introspections seem to indicate the following: (1) errors in pure sensory discrimination; and, (2), the fact that the attention frequently became focal at times in passages usually run without definite notice. Hence the subject perceived things he had been blind to before, and assumed that he was in a new situation.

(*e*) *Affection and Emotion:* The process of learning the maze elicited at times affective reactions that in some cases obviously influenced the progress of the subject. There were sufficiently in evidence, as one would assume, the feeling of discouragement in times of difficulty, and the corresponding state of elation when the difficulty was overcome.

The extremely disagreeable, hopeless feeling of being baffled very often resulted in a definite change of activity or method. Repeatedly, the subjects would find themselves in cul-de-sacs, would try at some length to extricate themselves by a study and exploration of the region, and would then resort in disgust to a random trial and error procedure in an effort to escape at any cost. It was extremely difficult to gauge the practical effect of this method. Quite often it resulted in discoveries of permanent value.

In one or two cases excitement over personal affairs distracted the subject's attention and the learning process suffered accordingly. Thus E. C. P. had just passed the German examination required of candidates for the doctor's degree a half hour before trial VII, and was in a state of considerable elation. Her record that day includes 75 errors, the most made by any subject in any trial.

This affective aspect showed itself most usefully in the incentive for quick learning. The sense of rivalry among the subjects was acute, and the learning was almost literally regarded as a test of intelligence. The experimenter kept each of the subjects sufficiently informed of the progress of the other learners to maintain this motive at a working level.

(*f*) *Thinking and Reasoning:* The reports of all the subjects have implied in them something more than the specific activities referred to in the preceding sections. Various indications have already been given to the effect that the kind of mental organization elicited was of an exceedingly complex sort. In some cases this amounted to overt attempts at logical reasoning; in all instances it seemed to have involved in it the rudiments of the higher thought processes.

While the problem was one in which a minimum of direct experiential background could be drawn upon by the subject, he nevertheless did avail himself of the general intelligence of human experience, in a way that an animal could not possibly do.

His general attitude, in the first place, was that of a learner who knows he has a problem to solve—certainly a rather important factor when one considers that the active effort of the learner was the thing that primarily characterized his activities.

Numerous specific reports indicated that the subject was able to call to his aid knowledge of a more general sort, and that he was able to conceive of working schemes not elaborated as the result of actual experience in the maze. Thus E. C. P. (IV) said the path was of the shape of the capital M. M. R. F. on the start conceived the idea of exploring one side of the path first.

An example of the realization and solution of a difficulty in a way that disclosed the attempt to rationalize the problem, and the amount of trial and error actually employed in its solution, is found in the experience of M. H. S. H., which is different from a number of instances given only inasmuch as it was more extended, and was elaborated more consciously.

During the first twenty trials, almost without exception, this subject went daily into cul-de-sac 6-7-8-9. During this time she constantly reported a tendency for familiar parts of the route

to drop into the habit class. Until about (XXV) she would go into this cul-de-sac every day, and retrace out of it, under the impression that she had made no errors. By (XXV), however, some cue given at the end of 9 made her aware of what she had been doing. She immediately began to study the situation. Since she had incorporated this into her true path—so she reasoned—how was she going to avoid it, since she did not know how much of the territory was cul-de-sac region? And since the cul-de-sac runs "up" (she meant of course either 6 or 9) and the true path also runs in the same direction, how was she going to be able to tell which was which? Her conception of the situation, as she explained, was that she gets into the cul-de-sac by turning *up* from some point on the true path. From (XXVI) to (XXXI) the conditions of affairs did not change. She had no feeling of being in error until she reached the end of 9, and practically restated her reasoning process: "I have to turn up to get out of the thing, this cul-de-sac also turns up, so there is no way to tell which is cul-de-sac and which is true path."

Curiously enough, in (XXIX) she ran the maze without error, but reported the whole affair as almost unconscious, and she was therefore unable to explain how she escaped from the cul-de-sac.

At (XXXII) the scheme occurred to her to avoid the region by turning up sooner in the path: "Will try this next time." In (XXXIII) she tried it but found no path, (i.e., in H) leading in that direction. However, she said at the end of this trial that the plan seemed logically sound, so she would try it again. In (XXXIV) she attempted it once more, with the same result, and reported, "Tomorrow I will turn *down* sooner than usual." (That is, some path that would lead from H to L, turning down from H.) This also failed. In (XXXVI) she got half way down 6, when the idea occurred to her that she had gone past the customary path downwards, that she was now in a new region, and that she had, therefore, better retrace.

In her next trial, the true situation occurred to her: not to turn down at all, in the path G-J. This solution of the problem came as the result of the fact that she had unintentionally and

accidently turned up in the trial previously made, and avoided the cul-de-sac.

This report suggested to the experimenter the advisability of making the amount of reasoning possible in such a situation the object of a more extended study, and with that purpose in view, the third experiment was designed.

4. A COMPARISON OF THE SUBJECTIVE ASPECTS OF THE LEARNING PROCESS WITH THE OBJECTIVE RECORDS

The criterion of five consecutive trials without error as an indication that the maze was learned was an entirely arbitrary one, even if the subjective aspects were not considered at all. Had the test been four trials, G. M. F. would have had the maze learned at trial XVII instead of at XXIII. If the standard had been determined at six trials, E. C. P. would have needed at least six extra trials. Several subjects ran occasional perfect trials in the earlier stages of the learning, before they were able to approximate a detailed description of the maze—E. C. P., XI; G. M. F., XIV; J. J. T., XIV; H. F. A., VI; J. W. H., XII; M. R. F., XIV.

Had a psychological criterion been attempted to determine when the maze was learned, e.g., the standard of ability to describe the true path, the test would have been just as arbitrary. With any subjective standard, the time and error records would be different from those based upon the objective test adopted—the number of trials would have been increased for some, decreased for others. E. C. P. described the true path accurately at the close of trial XXIII. H. F. A., when the maze was technically learned, described F as extending up from E instead of down, turning to the right, and then turning down to meet H. J. J. T. drew the reproduced diagram [Fig. 3] to represent all she knew of the true path,

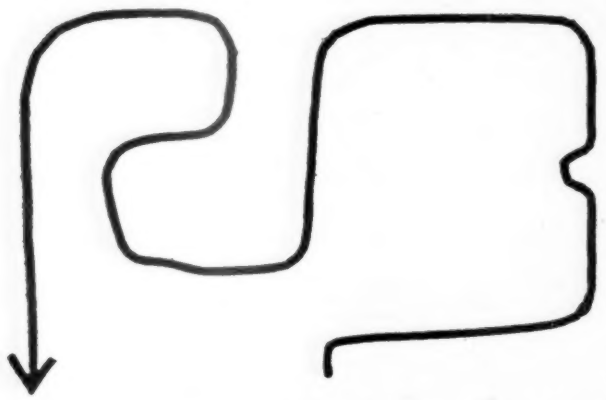

FIGURE 3. Drawing of Normal Maze, when learned, J. J. T.

after she had run it five times in succession without error. M. R. F. could describe the proper sequence of turns, but she still had the idea of other paths leading from the entrance to the exit. The fact is also to be noted that early in the series most of the subjects were able to describe *most* of the path—in the stage represented by trails VII-XV.

The essence of the explanation of the irregularity consists in the fact that to each subject the maze was a series of definite and relatively isolated problems, rather than one problem. The number of these special points of difficulty had as a rule dwindled down to one or two after the first VII-XII trails. From that stage on the attention was mainly concerned with these specific regions of trouble, while the rest of the path became almost automatic.

It is evident that the curve does not at any stage represent the development of the subject's knowledge of the maze path. A sudden increase in errors and time may indicate merely that the subject had seen fit to do some exploring, at the sacrifice of voluntarily playing havoc with his record: M. R. F., XXI; J. J. T., VIII; G. M. F., VI. Sometimes these explorations were productive of good results, sometimes not. Again, a sudden jump upwards of the time and error curves was the result of careless accident—the subject through lack of attention would slip into a cul-de-sac, even when he knew exactly the location of its entrance. Once in, he would get temporarily confused, and would escape often only after a trial and error expedient. An example of this is J. W. H. In this and in other cases, the attention had been uniformly concerned with the trial, but had suffered a temporary relapse. In other instances, a bad record was the result of general laxity of attention throughout an entire trial, or its direction to some extraneous affair.

The difficulty of the correlation of efficiency as measured by the total time involved in learning the maze, and the total number of errors made, is obvious from a glance at the following table. In the first place, this objective standard of efficiency is ambiguous. Time and error records represent only two of various possible criteria. The total amount of distance tra-

versed in the maze is a possible standard. Again, there are different methods of computing errors.

The total of the time and errors expended by each subject, in the order of their increasing excellence, is as follows:

Time		Errors	
M. H. S. H.	53′-58″	M. H. S. H.	644
J. J. T.	40′-14″	J. J. T.	412
G. M. F.	32′-32″	E. C. P.	285
H. F. A.	27′-58″	M. R. F.	279
M. R F.	27′-58″	J. W. H.	243
J. W. H.	22′-47″	H. F. A.	213
E. C. P.	21′-22″	G. M. F.	179

The relative predominance of a single specific activity involved in the learning process can hardly be called upon to explain the above lists of the subjects in their increasing order of merit, as the summarized data on these activities show:

Imagery: (a) E. C. P. employed visual imagery to the greatest extent, J. W. H. ranks next to her in this respect, and M. R. F. was a rather distant third. This would seem to suggest correlation between imagery and efficiency. But the two last used visual material in connection with other forms, and H. F. A., whose time record is very close to that of M. R. F., reports no visual imagery at all. The error column fails entirely to suggest a corresponding relationship between the use of visual material and success with the maze. (b) M. H. S. H. and H. F. A. represent the most exclusive emphasis upon motor processes; G. M. F. employed the same type of imagery, but complicated with verbal material. No obvious correlation in this respect is suggested. (c) It does not appear that a combination of image processes, such as was represented by M. R. F., G. M. F., and J. W. H., is to be directly related with skill in the maze.

Thinking and Attention: (a) M. R. F., who attempted to the greatest extent a rationalizing attitude, occupies middle ground in the matter of efficiency. It would be exceedingly difficult to determine how the remaining subjects are to be ranked as to the amount of thinking they did. M. H. S. H. has a considerable amount to her credit, but it was concerned with one particular segment of the maze. (b) On the basis of the

amount of attention paid to the maze, irrespective of the attempt at intellectualizing, E. C. P., J. W. H., G. M. F., and M. R. F. might be listed as representing the maximum amount, with M. H. S. H. and H. F. A. in an intermediate position ,and J. J. T. rather definitely employing the least. Again, assuming that this classification is adequate, it corresponds to the order of merit column only in a general way.

Habit: J. W. H. and M. H. S. H. emphasized the maximum amount as regards this factor, and with them H. F. A. should probably be placed. M. R. F. and J. J. T. report it to a considerable less extent; E. C. P., little or none. A correlation in this respect is again difficult inasmuch as this factor seemed to be detrimental as well as beneficial.

B. SOME EXPERIMENTS WITH MODIFIED CONDITIONS

At the conclusion of the experiment just described, it was thought advisable to supplement the study with a series of additional tests, designed, (1) to serve as a control over the data given by the experiment; (2) to bring out if possible any new data, or to enable us to emphasize aspects of the old. The instructions given for Experiment I were followed, subject to changes imposed by the modified conditions. The tests followed Experiment I in the order described.

1. Description of the tests, and results

Test 1. The subject was asked to go through a maze, the exact duplicate of the one just learned, but reduced in size to one-fourth the proportions.

Each subject made two trials in this smaller maze. Only one of them, E. C. P., made errors in the first trial. She made two, quite obviously due to the fact that her pencil became caught in one of the passages. A few errors were made by two subjects in the second trial, all of which were accidental in their nature, due to the more difficult technique as compared with that involved in going through the larger maze.

The introspections were unanimous to the effect that the con-

trols were the same. The subject, after he had traversed the first passage, formed an estimate of the relative lengths of the other passages, and went through the route correctly, with the errors noted. The various reports read: "Rather uncomfortable, but decided feeling of familiarity of the situation—used same control I used for the regular maze—outside of the novelty of the performance, the same factors were involved." All of them who reported the habit factor in the large maze, testified that it behaved in practically the same manner in this case.

The image controls were simply modified to meet the situation. E. C. P. says: "Used same visual image, *reduced* in size." J. W. H. gives practically the same report. G. M. F. used her usual verbal formula. The subjects employing motor controls report nothing new. They were simply adapted to a smaller objective situation. The habit element was distinctly functional. The increased mechanical difficulty of the operation however made the customary reliance upon it impossible.

Practically every subject, at the close of this test, was positive that he would be able to walk through a maze of the same pattern, blindfolded, with few or no errors. We append this as an indication of the introspective reaction of the subject on the modified condition.

Test 2. The subject was required to go through the normal maze with the pencil attached to the wrist instead of being held by the hand. For this test the pencil was firmly attached to a splint, which was bound firmly but comfortably to the wrist and fore-arm by surgeon's bandage. He was then asked to go through the reduced maze, used in test 1, with the pencil held in the hand, using finger and wrist movement only, the arm being held stationary on a support provided. This second part of the test required one shift of the arm, after the middle of the maze had been reached.

The idea in this test was to eliminate, in the first part of it, the kinaesthetic and tactual factors from the arm and fingers; in the second part, to cut out the same elements from the arm, as far as possible. Since test 1 had shown the same controls to be operative in the smaller maze as in the larger, we felt justified

in employing it for the second part of test 2, inasmuch as the task of going through the larger maze under the same conditions would have necessitated some half-dozen or more arm shifts.

About half the subjects made from 1-4 errors in the test with the wrist attachment. In order of importance, the causes assigned by the subjects were: (a) distraction of the attention by the technique of the test, (b) actual physical difficulty, (c) orientation: this was more difficult under these conditions, as the tactual cues which ordinarily told the subject his location were "blunted." They employed the projected tactual sensibility as best they could. J. W. H. reported that the tactual feeling was transferred, not eliminated.

Fewer errors were made when the smaller maze was run by hand movement only. The main difficulty reported was the sheer physical one.

It is noteworthy that while the subjects in Experiment I consistently emphasized the arm sensation factor more than the hand, more trouble was experienced in the test in which hand and finger sensations were approximately dispensed with, than in the hand movement test. In either case, however, the main emphasis was upon the mechanical difficulty of the process. The subjects were sure they did not, in the first part of the test, elicit hand and finger sensations from the hand, by incipient movements, and then transfer them. They simply utilized the sensations from the wrist instead. In a similar way, they did not evoke arm sensations or images in the second part of the experiment and substitute them for the same sensation normally called out by the actual use of the arm, but they transferred their attention to the fingers and hand, and utilized the sensations coming from them.

Test 3. In this test the larger maze was used, and the conditions were the same, except that the subjects were asked to use the left hand instead of the right, which was used by all learners in Experiment I.

All the subjects reported the process difficult because awkward, but all of them reported the some controls used. J. W. H., who is extremely right handed, reported an actual transference of

kinaesthetic imagery from the right hand and arm to the left. M. R. F. reports it "A transference, not a new learning process. It seemed queer, like the small maze." E. C. P. ran up 16 errors with the left hand in the first trial. She ascribed it however to sheer awkwardness, "the difficulty of doing anything with the left hand." She made no errors in the second trial. M. H. S. H., who depended so exclusively upon kinaesthetic cues and imagery, reported the process the same; it was essentially a transference. In all cases, the transference was made without special effort.

Test 4. Preliminary to this, and to all succeeding tests, the subject first went through the maze, normal running, in order to keep conditions as nearly as possible the same as they were at the completion of Experiment 1.

In test 4 the subject was seated in front of the standard maze, the usual conditions being observed. Instead of allowing him to begin at the starting box, however, the experimenter placed the pencil, upon which the subject retained his hold, in various places in the maze, both (a) in the true path, and (b) in cul-de-sacs. The subject was asked to proceed from these places to the exit, under the condition of a normal trial in the maze. At least 50 different tests were made for each subject, ten or a dozen being made at each sitting. The order was made as irregular as possible, to obviate any attempt of the subject to guess where his next place of starting would be.

The results from the subjects in this test were strikingly uniform. In every case, without any suggestions on the part of the experimenter, and without communication between the subjects, they made a definite judgment, after being placed in the maze, and before they started for the exit, as to their location. After this tendency was observed by the experimenter, they were asked to make their judgments aloud. The judgments were in every case based upon the cues furnished by the muscular and strain sensations from the arm.

In every case the success of the subject in going from the place of starting to the exit with a minimum of errors seemed almost directly proportionate to the accuracy of the judgment. In many

cases he made more errors when placed in the true path than when set down in cul-de-sacs—this, too, in view of the fact that no subject at this time could describe all of the cul-de-sacs, while all of them had a rather definite knowledge of the true path. In one trial that resulted in 15 errors, M. R. F. was set down just before the end of B, but made the judgment that she was at the beginning of G. She started left, was stopped after a short distance, turned up, and was stopped again. So far her experience fully substantiated her judgment. But when she attempted to turn left again (thinking she was on H), she found herself blocked. She reported a sudden and intense sense of absolute confusion, a realization that she was hopelessly lost: "If I'm not *here,* I haven't the slightest idea *where* I am."

This is a very characteristic description of the reaction that Test 4 elicited. If the judgment were inaccurate, the process was one of a trial and error moving around, trying to fit one idea after another to the cues furnished by the experience. Recognition or orientation might come after one or two turns, or might not come until after prolonged exploration.

As the tests were continued, all the subjects increased in their ability to form more accurate judgments. It was practically impossible for the experimenter to compare the relative ability of the different subjects, either at the beginning or at the close of this test, on account of the fluctuations, which were rather extreme.

Test 5. In this test the normal maze was used with the following modifications:

(1) The subject, after being blindfolded, was walked around the room in various directions before being seated.

(2) The chair, table, and maze, were rotated at various angles, 45°, 90°, 180°, etc., from their original position, in an irregular order, while their relative positions remained unaltered. The subject was then seated directly, and asked to go through the maze as usual.

(3) The chair was placed in different positions facing the maze, which, with the table, remained unaltered.

(4) The chair and table remained in their normal position,

but the maze itself was rotated, clock-wise and counter-clockwise, at all practicable angles.

(5) By means of a special apparatus, the maze was made to rotate, in either direction, *while* the subject was attempting to trace through it with the pencil. In all the other conditions followed in this test, no part of the apparatus was changed after the subject actually began the trial. In part (4), the maze rested upon a wood base instead of upon the plate glass, on the bottom of which three wheels were attached. These rested upon a circular track of wire laid upon another wood base, so that maze and upper base could be rotated in either direction, at any speed, by the hand of the experimenter. The apparatus worked smoothly, and was practically noiseless.

In general, very little disturbance resulted from the modifications imposed in the first four series of test 5. For (1) and (2) the subjects were unanimous in reporting that they were not in the least disturbed, that positive orientation did not bother them. All of them had previously been aware in what direction the chair faced. No amount of turning them around, in (1), enabled the experimenter to disturb their sense of position. No errors or increase of time resulted from (1) and (2).

The introspections from (3) and (4) were similar. The image controls were simply adapted to the new situation. The process, on the part of J. W. H., seemed to accentuate his imagery. E. C. P. said that her visual image was "turned around" to meet the new situation. With subjects who had emphasized kinaesthetic and tactual factors, the new conditions called out nothing new in these processes, notwithstanding the fact that for any turn or path of the maze, an actual different set of muscles might be involved from those used normally. There was with all a consciousness of a new arm position, and a consequent feeling of awkwardness, but the process, in this as in Experiment I, was one of controlling a certain sequence of turns. The kinaesthesis was built up in terms of this sequence. For tests (3) and (4) we recorded a few errors that were ascribed to general distraction of attention.

The rotating maze was, in the following order, (a) turned

slowly, at a uniform rate, in one direction, without any instructions being previously given to the subject; (b) rotated faster, at the rate of about one revolution per 10 seconds (the average time it took the subject to go from entrance to exit under normal conditions) in either direction, but constant for each trial, until the exit was reached; (c) rotated, during any one trial, in either direction, with frequent and variable changes of speed and direction.

The observation of the behavior of the subject when he first tried the rotating maze proved to be extremely interesting. The maze was moved very slowly. The subject covered about one-fourth of the path before he realized that something was wrong. Most of them became vaguely aware that something was unusual, and thought that the angles were being altered. Very few errors were made, however, during this trial.

In the series in which the maze was rotated slowly in one direction and at a uniform speed, the introspections were very similar to those given in (3) and (4) of this test. The subject first got the cue of the direction and speed of rotation from the sensations of the arm as he traversed the path A-B. He then tried to gauge his movements in terms of the new conditions. The visualizers testified that their visual image "rotated," keeping pace, and checked up by, the maze itself. They modified this statement to the effect that they visualized the pattern in a number of successive positions, which followed in general the rotation of the maze. Those employing other controls reported nothing not given in (2) and (3). All of them proceeded slowly and cautiously and very few errors were made.

In the last part of this test, in which the maze was rotated with all possible variations in change of speed and direction, the task of tracing through it proved to be either extremely difficult or flatly impossible. The subject could not get adequate cues as to the changes that were being made, or if he could, he was not able to control his movements quickly enough to get a new orientation before a new change was made. He was able to keep in mind rather clearly what path he had reached, but he was not able to proceed from there. If, e.g., he had reached the middle

of L, a few rapid turns would suffice to confuse his sense of direction, and he would not continue from sheer inability to tell whether he was headed for K or M.

Test 6. In this test the subjects were started at the exit, and instructed to proceed to the entrance. Otherwise, the conditions were the same as for Experiment I.

The task was not found difficult. Two subjects made errors the first trial, but corrected them easily. There was the tendency in evidence that characterized all the tests to accentuate the imagery employed. The introspections were in most cases practically a description of the objective behavior: they simply followed the path backwards. The motor subjects relied a little more on prompting by verbal cues, but the same kind of anticipatory motor imagery was reported. The habit factor was at a minimum for all the subjects, but after the test had been repeated several times it began to make its appearance at a relatively earlier stage than it did in the first experiment. In general, the trip was made by each subject reversing the various steps in his idea of the sequence of turns, in terms of the imagery he employed for every test. The usual kinaesthetic and tactual sensational cues were attended to for the purpose of checking up the control idea.

Test 7. The maze was turned upper surface down, and clamped to the plate glass as usual. Since the grooves were cut through the board, this reversal resulted in the "mirror" maze. The subject was told of the alteration before he made the trials.

Most of the subjects expressed surprise that the first trial did not prove more difficult. Some found it as easy as the backward running. The same introspections were given: an adaptation of the usual control imagery to the new situation, as checked up by the experience of actually going through the path and attending to the sensory recognition element. M. R. F. who used some visual imagery in test 6, as she had in Experiment I, reported herself as unable to visualize segments of the mirror maze, and consequently she relied on verbal and kinaesthetic cues. She found the process no more difficult however than that involved in test 6. J. W. H. and E. C. P. reconstructed their visual

images, making them "mirror" in form, to suit the condition. They reported them just as vivid as ever, equally stable, equally *adequate* for the purpose they served. The objective records for tests 6 and 7 were strikingly similar.

Test 8. This was in reality an elaborate series of tests designed as objective checks on imagery. The subjects were required to read aloud, to repeat different jingles in terms of auditory imagery, to follow a visual diagram perceptually, to following a moving light with the eyes, while tracing through the maze. They were given various tasks to do with the left hand while using the right in going through the path. Tests to eliminate and to control eye movement were introduced.

Our tests elicited the results characteristic of many tests for imagery: they practically amounted to general distraction tests. The tests were continued in the hope that even if they were of this nature, certain relative results would be obtained that would bring out the desired factors. That is, it was assumed that if any one of the tests were continued indefinitely, it would prove to be relatively *more* of a distraction test for the imagery aimed at than it would be for other forms of image processes. We were disappointed in this respect.

The results from the auditory-verbal tests, in the case of G. M. F., were relatively satisfactory. This subject was made to go through a maze for a number of trials, at the same time repeating "Mary had a little lamb," continuously to herself. She testified that it interfered seriously with her verbal formula. She was forced to "slip in" her verbal directions, between the words of the verse she was asked to repeat. The result was no errors, but a perceptible increase in time.

The visual distraction tests were productive of no positive results. They simply interfered with the attention involved in going through the maze. With E. C. P. the verbal distraction tests disturbed her visual imagery fully as much as did the visual tests.

Certainly, however, these tests offered no possible basis for challenging the introspections of any subject on the matter of imagery.

In connection with this series, three small and comparatively simple mazes were learned by each of the subjects by three respective methods of presentation of the true paths. (1) For the first maze the subject was required to memorize before starting a verbal set of directions which were typewritten and handed to him. They included directions for the true path, not for the cul-de-sacs, and began as follows: "¾ inch up—4 inches to right—4½ inches to left—1 inch down," etc. The subject was required to memorize this accurately before he was allowed to start in the maze itself. (2) In the second case, the subject studied a visual pattern of the true path, from which the cul-de-sacs were omitted, drawn on paper, of the exact size of the path itself. (3) For this presentation, the blindfolded subject traced through the maze to be run with entrances to all cul-de-sacs blocked.

The subject was asked to retain his hold on the maze in terms of the imagery used in the presentation of the path. He was not allowed a trial until he had satisfied the experimenter that he knew the path he was about to trace.

No subject was able to comply with the instructions as to the manner in which the path was to be retained in memory. E. C. P. studied the visual pattern as drawn and remembered it in the appropriate imagery. She also succeded in committing to memory the verbal formula in verbal terms, but was unable to refrain from translating this into a visual image when started in the maze. G. M. F. and M. H. S. H. were unable to remember the visual drawing as a visual image, but reinforced the scant image they got by verbal comment and kinaesthetic aids, before they attempted the maze itself. These three tests convinced the subjects that they had not been in error in their respective reports as to the imagery they normally employed. As for the objective results, the learning of the verbal set of directions proved to be by far the most difficult and irksome task they were asked to do. The learning by visual presentation was much easier for all, the learning by actually traversing the maze was accomplished with the greatest facility by all. There was little or no evidence of any correlation between the method of presentation and the

image technique of the respective subjects as to relative ease in learning.

2. Significance of the results obtained from tests

The data briefly given represent a summary of the evidence contributed by the tests. It substantiates the introspective testimony to the effect that the control of the maze learning process was largely an ideational matter. The significant thing, for instance, as brought out in the "mirror" test, was the ability of the subject to adapt his visual or other image, to manipulate it, rather than the fact that his idea was expressed in certain structural terms. Little evidence offered itself to indicate that the individual mental processes of any subject were relatively more adequate for some of the conditions than for others.

C. EXPERIMENT II

While the present investigation was concerned primarily with the activities of the human subject in the pencil maze, as a study of a definite learning process, it was thought desirable to introduce into the experimental work a maze through which the subject actually walked. The object was to determine whether or not different learning processes were involved in the two mazes calling for different kinds of physical technique. In other respects, the conditions were kept the same. The subject was blindfolded, was given practically the same directions used before.

1. Description of maze, and method

(*a*) *The maze:* The experimenter was saved the immense amount of time and labor necessarily involved in the construction of such a maze by the offer of one admirably adapted for the purpose of the experiment located in Forest Park, Chicago. This is one of the amusement parks of the city, and the maze, called the "Mouse-trap," had been used as a pleasure devise for several years. None of our subjects had seen it or heard of it.

A diagram of this maze [Fig. 4] is given on the opposite page. It was duodecagonal in shape, with the various paths arranged in concentric fashion, leading to the exit in the centre.

From the exit the subject ascended a circular stairway, and by means of a boardwalk on top of the maze, extending from the center on one of the radii and leading to a stairway outside the maze, he descended, thus obviating the necessity of returning through the maze.

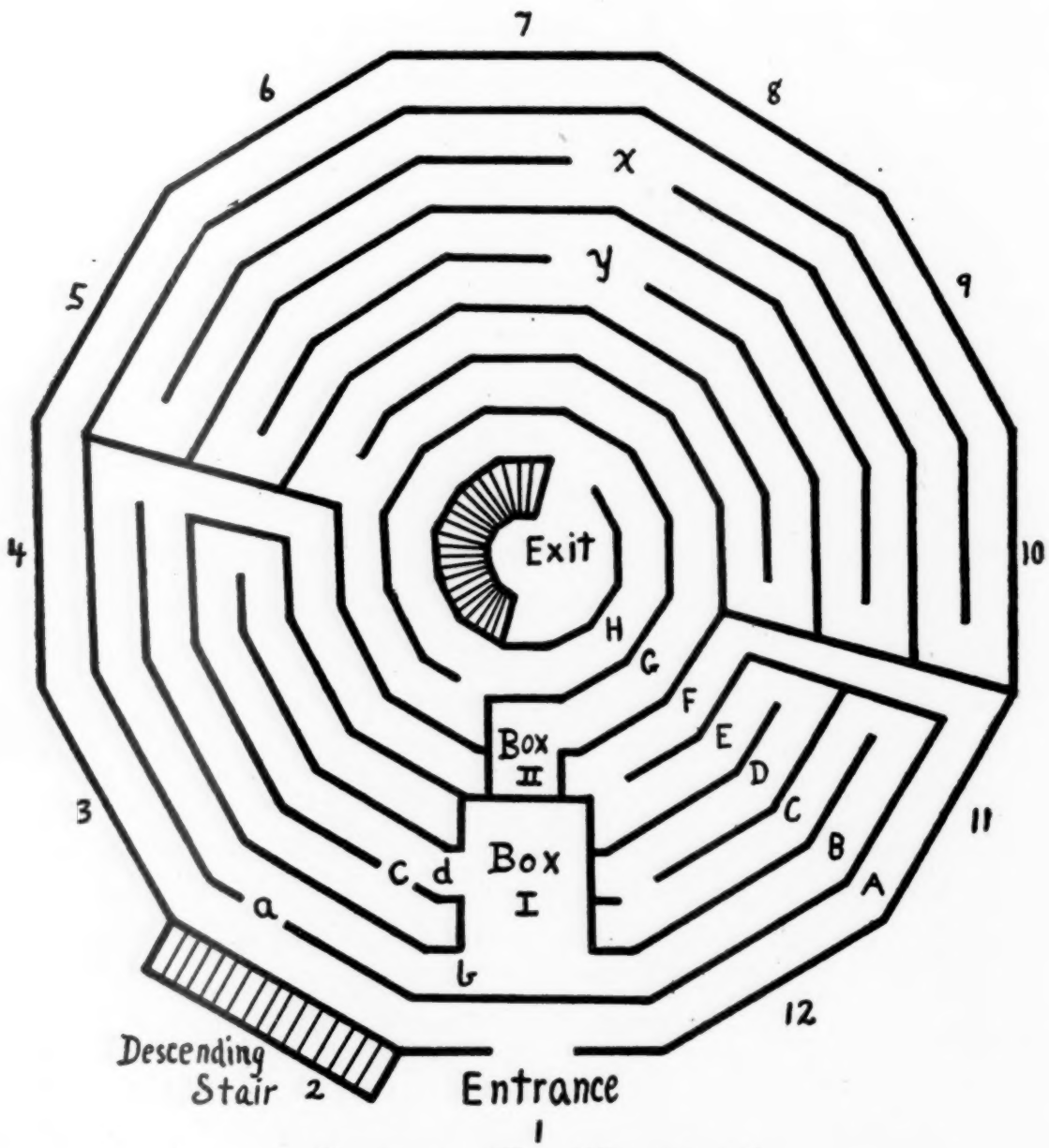

FIGURE 4. The "Mouse-trap."

The "Mouse-trap" was constructed of sections made of wire netting, bordered and held together by angle-iron. The wire was of uniform size, about a 12-gauge, woven into a diagonal 1½ inch mesh. The maze rested upon an even wood floor, elevated about 6 inches from the ground. There were as many sections, in any one partition, or in the outside wall, as there were sides of the duodecagon around which the partitions extended.

The maze was covered by the wire netting, divided into 12 sections, each section corresponding to a sector of the top. From floor to top the height was 7 feet; each alley was of uniform width, 2 feet 4 inches. The length of the sections making up the outside wall was 12 feet 2 inches, so that the circumference of the maze measured 146 feet. The exit box in the center, from which the stairway ascended, had a diameter of 9 feet 4 inches. All openings or doors were of the same width as the alleys. Two box-like areas were located, as is seen in the diagram, in section 1 of the maze. One of these, which is referred to as Box 1, was 8 feet in width, 9⅓ feet in depth; the second enclosure, Box 2, was of the same width, and was 4 feet 8 inches in depth.

The maze was in the open, and side 1, on which was the entrance, faced the north. The floor was perfectly level.

(*b*) *Method of conducting the experiment:* The subject, after entering the park, was led directly to a small building about 60 feet northeast of the maze, conveniently situated so that he did not see any part of it. There he was blindfolded as in Experiment I, and led to the entrance. He stepped upon the platform, rested his two hands on the two sides of the entrance door, and waited until the experimenter mounted the overhead walk and gave the signal, "start."

The directions and instructions given in the preceding experiment were modified to the following extent: The subject is permitted to use both hands as he wishes, getting with them all the tactual cues possible. (This allowed him to feel the floor if he so desired, but only one subject resorted to this, in one trial, and he soon gave it up as useless.) He was permitted to walk forward or backwards, run, or carry himself in general as he saw fit. The maze was considered learned when the subject had gone by the shortest route from entrance to exit three times in succession without error. The mention of more than one possible path was made for this experiment in the same manner that it was in the previous one. In this case, however, there was an actual option of paths.

The experimenter stood quietly upon the platform and wrote down, in addition to the time, a literal account of the route each

subject followed for each trial. This was not an especially difficult task, as the actual time involved in walking gave the observer ample opportunity to take complete notes of everything he desired to record. The experimenter was careful, except in one or two exigencies, to say nothing to the subject, who, however, was encouraged to express his introspections or comments aloud, to any extent which did not act as a distraction. The subject was told absolutely nothing of the plan or construction of the "Mouse-trap." It was simply "a maze," which he was to learn by walking through it. When the learner reached the exit box at the end of the first trial, he was told to "stop." In the ensuing trials, he had no difficulty in recognizing it. He was led, still blindfolded, over the walk, down to the ground, and back to the building mentioned, where the bandage was removed and the introspections were called for.

Owing to the distance of Forest Park from the psychological laboratory, it was practically necessary for the subject to make the trials in succession, with intervals of 10-15 minutes for rest and introspections. Each subject spent a good half day at the performance; two of them made two trips before they learned the maze. The experiment was conducted in October, 1911, and the following were induced to act as subjects: J. R. A., M. R. F., W. S. H., E. W. B., R. B. O.

2. The objective behavior of the subjects in the maze, and the nature of the learning process

(*a*) *General description of behavior:* There were very few individual differences to be noticed in the behavior of the subjects. They proceeded very cautiously, especially for the first few trials. Both hands were employed in feeling the sides of the alley ahead for the openings. Several times during the first or second trial the subjects became so engrossed in the search for openings that they ignored the possibility of blind endings in the path, and a few unlooked for bodily contacts with the ends of blind passages resulted. This happened a few times in the later trials, as the result of over-confidence in their ability to guage the lengths of various passages. As they learned the path,

the speed was increased in familiar regions from a blind man's walk to a brisk half-walk and half-trot. Most of the learners, when they had reached openings, would stop for the purpose of studying or attempting to remember their location. When either of the two boxes were entered, the subject would as a rule keep one hand in contact with the side, for the purpose of retaining his orientation, and reach as far out as possible with the other. No subject attempted walking backwards, or any other pronounced variation from the regular procedure. They would occasionally stop and face in different directions, in an attempt to get a better orientation.

One subject, J. R. A., in the absence of directions to the contrary, wore gloves in practically every trial. Several of the subjects at different times availed themselves of this protection from the metal. As will be mentioned below, this did not interfere with the tactual discrimination employed.

(*b*) *Nature of the learning method:* The variation in method in evidence in the pencil maze was not so pronounced in this experiment. The introspections were more similar to those of M. R. F. in the normal maze. They indicate a more persistent attempt at studying out situations. No subject reported complete reliance on the hit-or-miss method of H. F. A. The fact that the subject had more time to think or plan in the "Mouse-trap" partly acounts for this, and the reports indicate that the greater complexity of the maze itself called for more intensive study. There was however a rather sharp fluctuation between periods of study and directed exploration and periods of aimless trial and error with four of the five subjects in the first trial.

(*c*) *A report by trials of the learning behavior of one of the subjects, and a brief description of the learning of the others:* In the following account, references to segments of the maze are abbreviated as much as possible. Thus, 2-3 refers to the general segment corresponding to the first three sectors of the maze to the left of the entrance, while 2-4 on B indicates one path in that segment. The designations given in the drawing of the maze are followed in this description. The record of R. B. O. was selected as the one best suited to give the reader an adequate

description of the type of learning activity elicited in the "Mous-trap, because this subject had the most difficulty with the maze, and the steps in his learning were more elaborated. The reports of the other subjects had implied in them the same activities found here.

(1) Subject R. B. O.: Trial (I). This subject occupied 1 hour, 15′, and 47″ in finding the exit to the "Mouse-trap," and at the sacrifice of 112 errors, in his first trial. His exploration was divided up as follows: (a) In the first attempt he turned right and entered 11-12, which, with the 2-4 section through Box 1, he went through several times. (b) He started left from the entrance and explored section 5-10 at length, but worked back to the entrance before getting further on the true path than E. (c) The third attempt was largely a repetition of (a). (d) Again he followed A around to 10, failed to find the exit, and ended up in Box 1. This was followed by a prolonged entanglement in sections 2-4 and 11-12, during which Box 1 was entered several times. (e) The exit was finally gained in a last effort in which the whole region 5-10 was worked over in detail.

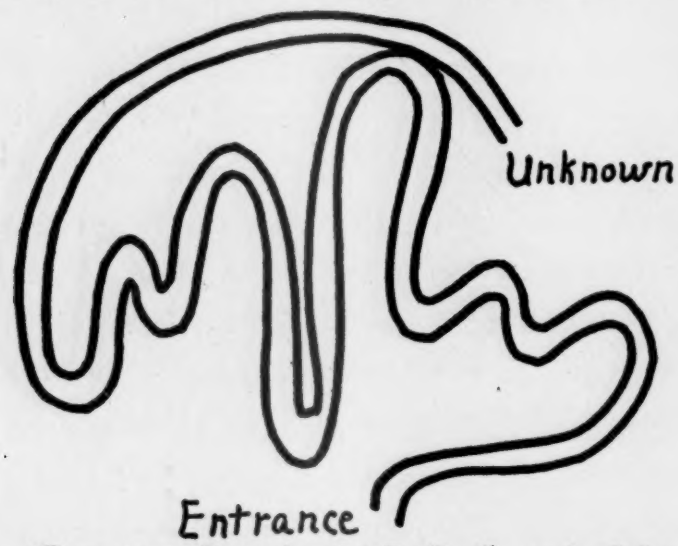

FIGURE 5. Drawing by R. B. O., end of first trial. Figures 5-10 are exact reproductions of drawings made by the subjects.

The report, like the behavior, followed M. R. F. in her first trial. He successively alternated between trying to keep his bearings as he went, and giving himself up in an aimless fashion to whatever he chanced to find. This variation of working methods did not carry with it any perceptible change in objective behavior, but the subject kept the experimenter informed of his fluctuations by such comments as: "Now I'm not going to think for a while," and "Guess I'll study this region." Like M. R. F., his knowledge of the maze acquired as the result of the first trial was vague and confused. [See Figure 5.] Like J. R. A., referred to later, he had conceived the exit to be on the outside and was controlled largely by the general idea of working in that direction.

Trial (II). In his second trial, the subject again started to

the left, came out through Box 1 to A, which he followed to 10. He called A a circle. He became confused by the doors *x* and *y*, and found himself back at the entrance. A second attempt was largely a repetition of the first, but resulted eventually in his gaining the exit. Time 17″-24″, errors 31.

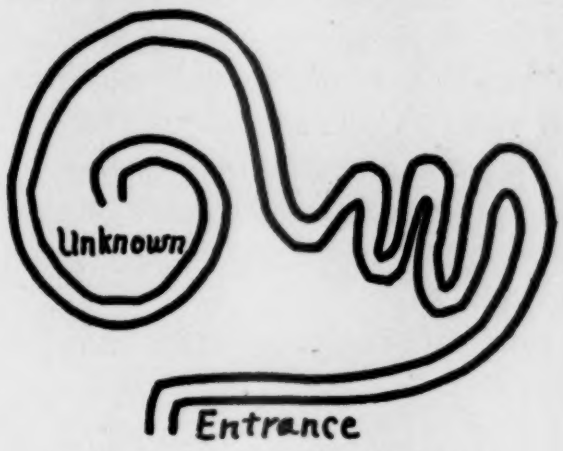

FIGURE 6. End of trial 2.

The main idea the subject got from this trial was the circular nature of the paths, indicated in his drawing. [Figure 6.] Several places were recognized as familiar. He was very much bothered by the two doors *x* and *y*, and could not figure out what connections they made.

Trial (III). After going through the region 11-12, through Box 1, and gaining the entrance by way of *a*, the subject gave the information aloud that he had learned something: "If you go straight across the Box (i.e., along B) you come out at the entrance. Therefore avoid that path." In the obvious attempt to profit by this discovery, R. B. O. after entering the Box again by his circuitous route, searched around for other exits. This led him into D, and the region 2-4 was thoroughly explored in an attempt to find the circular path. This process was repeated, until in desperation he decided to retrace from the Box to the entrance, and then go where "instinct" would guide him. As a result of this retracing, he got started on A, followed it around past the entrance to 10, and finally made the exit.

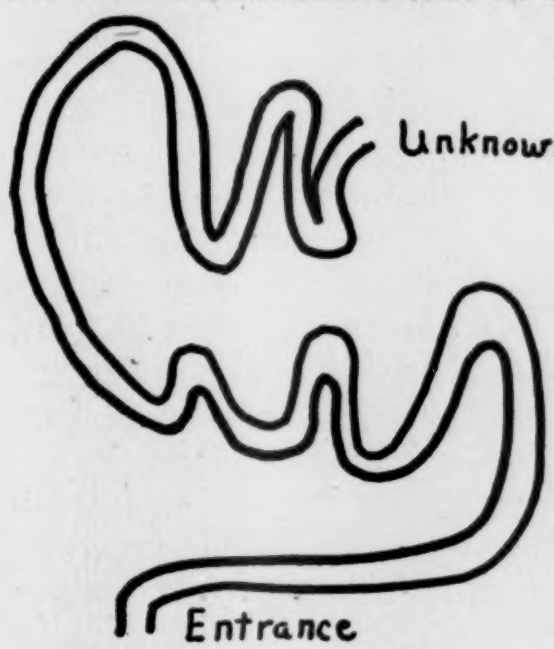

FIGURE 7. End of trial 3.

R. B. O. describes this trial as "pretty much hit or miss." He doubts if it added to his knowledge of the path—he rather thought he knew less than at the end trial (II). [See Figure 7.]

Trial (IV). The subject did not learn from the last trial's experience that he should start directly to the left. Accordingly

he started on 11-10 and found himself as usual in the Box. As a result of a considerable amount of exploring in 2-4, he decided on door *d* as the correct way out of the open space. In an attempt to act on that conclusion, the subject repeatedly walked back and forth in C D E F, in the region 2-4. After this exploration he concluded that B after all was the correct way to escape from the Box, and after more experimentation he discovered that *b* and *a* led him from the Box to the circular path. Once in the region of the doors *x* and *y*, however, his difficulties were renewed, but he finally reached the exit.

R. B. O. describes this trial as much more systematic than the last two. He did more planning, more rational exploring. He was able to do so because turns and passages were becoming familiar, and he could retain more in memory, and therefore *think* better. He describes the process as one of "exploring, and building up the path." His actual knowledge of the maze, however, as expressed in his diagram, does not differ much from what he had known before. [See Figure 8.]

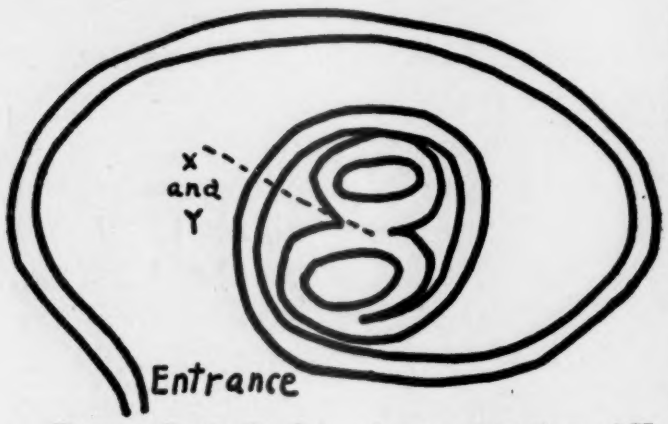

FIGURE 8. R. B. O.'s: first conception of X and Y. End of Trial 7.

Trial (V). In this trial, R. B. O. learned to start to the left directly from the entrance, and thus avoid 11-12. This he calls a purely accidental discovery. He made no headway, however, with the regions concerned with *x* and *y*. No matter what way he turned, he got back to the door *a* again—he did not know whether or not there were two doors. His knowledge of the maze was increased, but every new fact, he stated, was the result of accident: "The best intelligence I have doesn't get me anywhere."

Trial (VI) objectively represents the greatest drop in the learning curve, but it was the result of chance, the subject thought, and did not represent any correlated addition to his conception of the path.

Trial (VII). In this trial the center of study shifted entirely to the doors *x* and *y*. The net result of an exploration in that region he expressed as follows: "Turn any way you want to, at this door, and the chances are that you find yourself back at it after a short time." He repeatedly, after reaching *x* by turning into B from A on 10, would continue on B to 5, come down

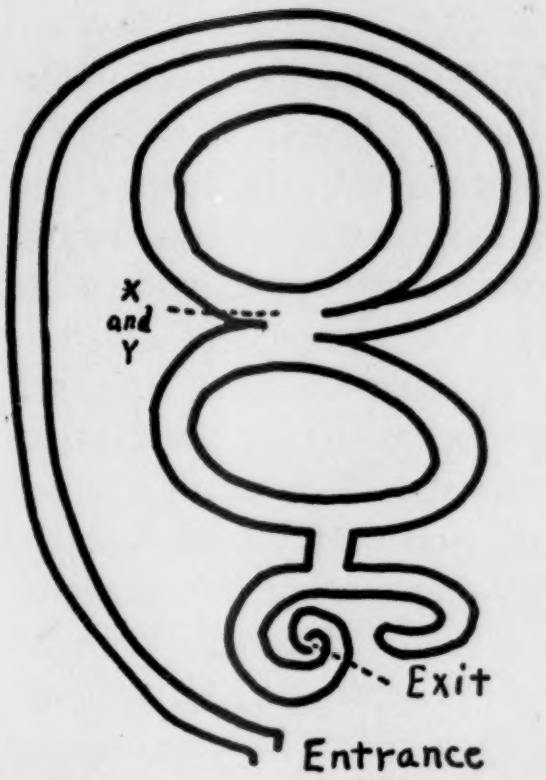

FIGURE 9. Second idea of X and Y. Early part of Trial 10.

C and find himself at the same door again; or would turn correctly at *x*, come back on D, and again find what he thought was the same door. He studied long on this problem, but was unable to figure out what possible arrangement of paths and doors could result in such an experience. The first explanation that he gave was that the maze was a figure 8, and that the true path intersected at this door. He reports himself at the end of the trial as "Completely baffled—I know less than I did at the beginning."

Trial (VIII). While this trial was made with only three errors, he made no progress in the difficulty of the last trial, and still believed the maze was a figure 8. [See Figure 9.]

Trial (IX) was a repetition of (VIII).

Trial (X). The intellectualizing in this trial consisted in a prolonged attempt to imagine different spatial possibilities, and explain his experience in terms of them, of the region in the vicinity of the two doors. The diagrams drawn by the subject represent his three conceptions of the region, in the order of their elaboration. [Figure 10.]

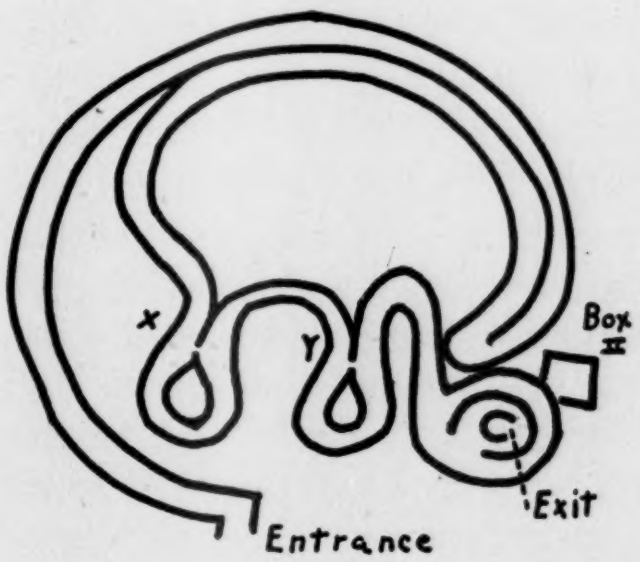

FIGURE 10. Final idea of X and Y. Trial 10.

Trials (XI-XII-XIII). No errors were made in these trials and the maze was called learned. Since the explanation he had last elaborated *worked,* he "let it go at that" as he said in the last trial, and concerned himself only with the task of making the right turns.

(2) Subjects E. W. B. and W. S. H.

The records for E. W. B. and W. S. H. were similar to those of the subject just described, but indicate less trouble with the maze. Neither of them had the difficulty with the doors *x* and *y* that was the source of R. B. O.'s confusion. The drawings they made after each trial are quite comparable with those reproduced.

The learning of W. S. H. offered one peculiarity, inasmuch as he was unable to learn the maze technically, in the trials he made because of the fact that he did not discover the shortest path. This subject, at the end of trial (XIII) reported the maze "learned"—that is, he had gone over what he considered the true path three times without error. He had, however, incorporated the section 11-12 into his route, and hit the true path after going through Box 1 and door *a*. He had not doubted for an instant that this section was part of his regular course.

Since the experimenter had asked for the shortest path, he informed the subject that he had not fulfilled the conditions of the experiment in this respect. The statement was made that there might be an absolutely new path, or that his error consisted in not discovering one or more short cuts in the path learned. The subject then started on a new trial.

In this new trial W. S. H. started directly to the right several times, and attempted to discover a short cut from Box 1. After each attempt he followed the old path, and worked in 5-10 for a shorter route in that region. Curiously enough, in one attempt he started directly to the left and followed the shortest path to *x*, but he got confused in that section, retraced, and found himself back in Box 1 again. On the basis of this experience he dropped the idea of starting directly to the left. After two more trials in which no more headway was made, the lateness of the hour prohibited additional experimentation, and the maze was called "not learned."

(3) Among the remaining subjects, M. R. F. had the most difficulty, with E. W. B. as a close competitor, while J. R. A. has the smallest number of errors and the minimum amount of time to his credit. The first trial of M. R. F. occupied 1 hour, 20′,

and 56″, and resulted in 175 errors. The chief landmarks she discovered in the early part of the trial were the "box," and path A, which she described as "some considerable curve." As in the case of R. B. O., the doors *x* and *y* were the occasion of much wonder and not a little disgust. The first trial was characterized by sharp alterations between the methods of trial and error, and attempted systematization of her attempts. On the whole, her learning seemed to follow the procedure shown by R. B. O. The efforts of E. W. B. in their essential aspects were in turn very similar to those of R. B. O. and M. R. F. J. R. A. started in with the preconceived scheme to follow consistently the right side of the path. This led him in his first attempt almost directly to Box 2, but it also led him back to the entrance from that place. Although conscious that the path seemed to be a kind of narrowing spiral, the conception of a side exit was sufficiently strong to shut out any idea that it was in the center. The exit was discovered by pure accident. J. R. A. elaborated a definite verbal formula, which read, beginning at the end of A on 10, "right—left—right—left—right—right—left." With its aid the path was learned successfully in short time.

3. Summary and Analysis of Some of the Specific Aspects of the Learning

(*a*) *Imagery, and sensory processes:* In general, image and sense material functioned in the same manner that it did in the first experiment, but some differences in the behavior of these processes in the respective mazes were in evidence. The tactual element was emphasized much more strongly, as was to be expected from the fact that in this experiment the hands were actually employed in feeling the sides of the maze. Since, however, the partitions were made of homogeneous material, and the openings were similar in size and construction, the subject did not succeed to any marked extent in recognizing familiar landmarks by tactual cues alone. One subject, R. B. O., searched the floor for irregularities to serve as points of reference, but was not successful in this attempt. The hands and arms were used mainly in informing the subject when doors were reached, and in

keeping him from walking into blind alleys, rather than in making fine discriminations. Hence those who used gloves found that they did not seriously interfere with this tactual function.

The reports on imagery follow closely those made in the pencil maze. Verbal processes seem to have been called upon somewhat more freely, both by way of comment and elaboration of formula. Verbal material was used in two ways (1) in the "building up" process, of discrimination and association—that is, in studying out situations. (2) It was employed to fix landmarks or regions of crisis—that is, the verbal formulas used consisted of directions, associated with particular doors. While R. B. O. *knew* the maze in terms of visual imagery, he had used verbal material in building up this knowledge, in working over confused details. W. S. H. also used verbal material in this way, and consequently reported it as dropping out towards the close. E. W. B. used words to "start" himself—e.g., "Now I'll do so and so."

Visual imagery was reported by W. S. H. to be more accurate than the verbal or kinaesthetic which he also employed. It was the visual scheme which "set" him in the right direction at diverging paths, as over against kinaesthetic, which was more general and vague. But M. R. F. used relatively less visual than she did in the pencil maze.

No subject reported the use of only one type of imagery, as was done by one subject in the pencil maze, W. S. H., who represented a combination, used verbal in some regions, kinaesthetic in others, both mixed with visual. This using of different kinds for different segments was also reported in the preceding experiment.

The slight differences we have noted in the use of imagery may be merely matters of individual variation, or they may be explained by the fact that the trials were longer in time, than in the pencil maze, and allowed more time for studying or memorizing, and as a consequence elicited more verbal material. It was not evident from the introspections that imagery was employed in different ways, although the body itself was in motion in this experiment, while it was a stationary point of reference in the pencil maze experiment.

(*b*) *Habit and Attention:* We did not discover the appearance of habit, in the sense of paths being run unconsciously, to the extent that it was manifested in the pencil maze, nor did the introspections indicate much reliance upon this factor when it did appear. Probably this latter statement is the more significant one. In the pencil maze, the subject made, in any one path, a vigorous sweep with the pencil and was stopped rather violently by the end of the path. The greater complexity of the act of walking in narrow confines, and the fact that sudden contact with the end of a passage involved physical discomfort, was the explanation the subject gave for the greater amount of caution used in the "Mouse-trap."

Again, there was more variation of objective behavior possible in this maze. Any given sequence of turns was actually made proportionately a less number of times. In any cul-de-sac in the pencil maze, the subject who had entered it, was forced to "back" out. Cul-de-sac regions in the "Mouse-trap" were open at either end, such as 11-12, or B C D E in 5-7.

The introspections on the last trials however, disclosed on the part of R. B. O. and W. S. H. a decided tendency to let down on the active attention formerly used—a stage which in the pencil maze was the fore-runner of automaticity.

The attention during the learning was directed in the same manner that it was in the preceding experiment, and but one point of distinction appeared in the reports. As before, it was either retrospective, engaged with present experiences, or anticipatory. In this latter aspect of its behavior, the reports in the pencil maze were to the effect that it was concerned with the turns to come as expressed in some image form. In the park maze, there was a report from M. R. F. that her attention was at times concerned with a more general state of expectancy, or surmising, or guessing. Other reports seemed to indicate a tendency towards this same type of anticipatory attention. As the maze became controlled, the anticipation, as before, was on the turns in front of the subject. The distinction seemed to be a relative one.

(*c*) *Discrimination, Memory and Recognition:* The fact was

mentioned above that the maze was composed of homogeneous material, and that fine tactual discrimination was impossible. Discrimination of the less immediately sensory kind, that involved in ascertaining the nature of the paths and cul-de-sacs, had in it therefore, less of the purely sensory element than the activity in the pencil maze. It was of the kind that called upon the ability of the learner to interpret experiences by thinking, applying concepts.

It was assumed by the experimenter that the subject would in the first trial, as a matter of discrimination and interpretation of direct sensory experiences, gain the idea of the segmental and curved nature of the paths, and would be able to interpret the paths as belonging to a concentric system. Since the subject kept one hand in constant contact with one of the walls, and since the lengths of the segments decreased as he went towards the center, it was thought that the angle of 30° would be sufficient to furnish him ample cue for this conception.

As a matter of fact, all of them did note that the paths were irregular. One other subject, with M. R. F., observed in (II) that the path A had "some considerable curve." They were a long time however in getting the concept of the nature of the paths; and they were decidedly late in hitting upon the idea of the concentric arrangement of the paths. Some of them hardly got the idea at all. The drawings reproduced above sufficiently indicate the tardiness of the subjects in discriminating and interpreting the sensory experiences of the maze.

Inasmuch as discrimination did not differentiate the various paths to a degree that each of them presented distinct peculiarities in curvature and length, the number of regions that early became definitely familiar was small. Box 1 was a landmark for everybody from the start. The doors *x* and *y*. were distinct from others doors, but being in themselves alike, they were a source of confusion to all of the subjects. The region 11-12 early was recognized, inasmuch as it was a series of alternating paths without outlets. The region 2-4 was the area of greatest confusion. It was complex in arrangement without offering landmarks, and it was not learned by any subject.

In the pencil maze, the fact that the body was a fixed point of reference aided the process of discrimination and recognition, since it, (1), gave the subject a fairly accurate idea as to what part of the maze, (right, left, upper, etc.) he was in; and, (2), gave the subject an immediate cue as to the direction of any one path. In the "Mouse-trap," the absence of this reference point, together with the fact that any one path was not a straight run, but was composed of segments, and was therefore curved, tended to make these judgments much more difficult. The park maze, presenting as it did, more variations in cul-de-sacs types, instead of offsetting this disadvantage by way of holding out more individualistic segments, resulted in confusion, because of its complexity. The most difficult region in the pencil maze, was the most complex cul-de-sac, 6-9, which was simply an inverted capital T. As compared with the 3-4 region in the park maze, it was exceedingly simple.

Memory in both mazes was obviously employed in two ways. (1) Remembering the path, after it was once learned, was one of the things the subject would be assumed to effect. Practically, this meant, however, the ability to remember crucial turns in the path, where opportunity for error was present. J. J. T. and others, when the pencil maze was learned, were not able to describe the true path, since they had memorized only the important segments of the path. (2) Studying the way out of difficult regions consisted largely of calling up and applying memory experiences.

The second function of memory was relatively put under more strain in the "Mouse-trap" than in the pencil maze. Once they were learned, the two respective paths were remembered with relatively equal ease. While the route in the pencil maze consisted of 32 turns as over against 9 in the other, the important thing was the number of opportunities for error in the two paths. There were 6 cul-de-sacs discharging into the true path in the pencil maze, and 9 in the park maze, but only two of these, *x* and *y*, proved especially difficult to remember.

We did not find that the differences in physical technique in the two mazes influenced the process of memorizing, by way of making it either more or less difficult.

(*d*) *Illusions:* Evidence has already been offered to suggest that, as in the pencil maze, the number of spatial misconceptions was pronounced. The reproduced drawings given above indicate the nature of these illusions or misconceptions.

In another way, this phenomenon was brought out. The subjects were allowed to see the maze after it was learned. Most of them expressed intense surprise at the small size of the "Mouse-trap" when actually seen. For W. S. H. it dwindled down to one-half its size. R. B. O. made the proportions in the same directions, 5 to 1. Other subjects were more numerically conservative in the same judgment with the exception of E. W. B., who reported the maze as larger, not smaller, when actually seen. This subject had made rather accurate estimates of dimensions while learning the maze, but some of the essential ones had been smaller than the segments measured.

(*e*) *Emotion and Affection:* The "Mouse-trap" seemed to elicit the unpleasant reactions more than did the mazes used before. The work was more physically fatiguing, and the feeling of being hopelessly lost was more in evidence. M. R. F., towards the close of the first trial, was once at the point of declaring that she could not learn the maze. There was, however, a corresponding elation when significant discoveries were made. Only in the case of W. S. H. was the feeling of being baffled in evidence towards the close, when he was directed to discover the shorter route. This, with the fatigue that had developed by that time, influenced the course of his learning.

Emotional disturbance, however, played a positive rôle in the learning of this, as well as the other difficult mazes. They represented periods of intense consciousness, in the same way that periods of mental effort meant a heightened consciousness. In either case, this consciousness was called into being when the need of readjustment was imperative. Current psychological doctrine asserts that cognitive activity functions in times of conflict, and while it assumes that emotion also arises under similar conditions, it has not assigned to that state any definite function. That function, in the maze learning process, is indicated in the introspections.

The subject described his efforts, while under the stress of such excitement, as pure trial and error; but they actually represented an entirely different thing from the listless, random exploration that was on other occasions characterized by the same subjects in these terms. In the first place, the subject was more, not less, sensitive to the significance of the attempts he made. He was decidedly on the alert for possibilities. Hence, discoveries made during these periods were utilized and reacted upon as quickly and efficiently as those which were the result of careful study. Secondly, the effort was not directed by any interpretation or theory—they were practically thrown to the winds. As a result, openings were entered that were normally labeled as cul-de-sacs, and avoided. It was the effort of the drowning man to clutch at the last straw; and such an expedient often turned out to be highly successful in the maze. S. M. R. discovered the exit of maze M in such a period during which, out of sheer desperation, she entered the cul-de-sac complex which in her rational moments she had avoided.[3] In general, emotion was the incentive to a more inclusive series of exploratory movements than was the case when these attempts were controlled by ideas. Emotion very often meant increased effort upon new lines, made possible by the discarding of old conceptions and theories; but the value of the reactions was not lost sight of, hence they were often productive of positive results. Obviously, emotion carried to the extent of surrender, to a cessation, rather than an increase, of activity and effort, would defeat its own purpose, as it very nearly did in the two cases mentioned.

(*f*) *Thinking:* The fact that all the subjects who had serious difficulty with the maze alternated frequently in the first trial between periods of active study and periods of relatively aimless trial and error has been mentioned. It indicates that there were definite periods in the subjective aspect of the learning process in which the higher mental activities of the learners were called into play. This fluctuation also characterized the subjects in the pencil maze, possibly to a less extent.

The experimenter assumed, at the beginning of trials, that the

[3] *Cf.* Experiment III.

"Mouse-trap" afforded more opportunity for study, for thinking out situations, than did the pencil maze previously employed. Its cul-de-sac formations were more complex, and a richer variety of experiences, it was thought, would present material for a more complex type of mental reaction.

As a matter of fact, our assumption turned out to be correct inasmuch as the attitude of the four subjects resembled that of M. R. F. in the pencil maze more than it did that of H. F. A. For J. R. A., the maze was learned too easily to elicit that subject's method of thinking out such situations. The quality of the attempts at rationalizing, however, seemed to be quite comparable with those brought out in the previous experiment.

None of the subjects guessed or reasoned that the exit might be in the center, rather than on the outside of the maze. Predilection was against them, it is true, on this point: those who had previously worked with animal mazes were accustomed to the side exit formation. But after J. R. A. had in the first trial followed the true path almost directly to the center, and had discovered rather definitely the concentric nature of the paths, it did not occur to him that the exit was possibly there. Two subjects reported that in the first trial they were definitely working for the outside. They did not question the presumption that the exit would be here.

As in the pencil maze, and to a greater extent, general working ideas were in evidence—definite rational methods of attack. Thus J. R. A. and M. R. F. resorted to counting their steps in specific places where estimations of lengths were desired. The scheme to follow all turns to the right, or to the left, the plan of R. B. O., (IV), to locate various central points of reference, and work out in all directions from these, and even the deliberate adoption of a random hit or miss method are examples of the general control ideas—ideas that were the result of definite judgment to the effect that they might prove efficient.

The actual efficiency of these general methods was extremely hard to determine. J. R. A. hit upon a plan that resulted in speedy learning. M. R. F. conceived the same idea, but it did not work for her. She had also, in Experiment I, in the corre-

sponding trial (I), attempted and dropped this working scheme.

The extended study R. B. O. made of the doors *x* and *y* has already been described. It seemed in every way comparable with the study made by M. H. S. H. of the cul-de-sac 6-9 in the pencil maze. It certainly involved the mechanism of the reasoning processes: it was something more than sensory discrimination, or imagining, or memorizing. But the actual solution was an accidental discovery.

The difficulty of labeling the type of mental activity in evidence was as obvious in this experiment as in the previous one. W. S. H., after being informed that he had not discovered the shortest path, actually did go directly from entrance to door *x* in his endeavor to find the short cut. His attitude was one of sharp attention—he was on the lookout for cues, he was doing all the thinking he could do. But with all that effort, he did not interpret sensory experiences in an adequate way. Systematic thinking seemed to be extremely difficult, or impossible.

4. The objective results

The objective records, presented in the form of curves, show a relatively different distribution of time and error from that of the pencil maze. A greater proportion of effort was centered in the first trial, in this experiment, and the ensuing trials are more free from irregularities.

The introspections, and the fact that the records from the pencil maze employed in Experiment III are comparable with the results from the "Mouse-trap" in this respect, indicate that the cause of the relative difference in the distribution of effort is to be looked for in the plan of the maze, rather than in the fact that it was a maze calling for a different physical technique, or other factors.

The reports on the rôle of discrimination and memory explain the relatively greater emphasis on the difficulties of the first trial. By far the most difficult part of the maze was the half on the entrance side. This was practically one system of cul-de-sacs, since only one door opened into it from the true path, in addition to the option offered at the entrance. An immense

amount of exploration was necessary for the subject to learn *not* to enter door *a* and *not* to start to the right. These items, once learned, were easily remembered, while the actual scheme of these cul-de-sacs was speedily dropped from memory. On the basis of similar records from Experiment III we might assume that a maze of this type would tend to throw the emphasis on the first trial, while a maze consisting of a long true path, with a number of cul-de-sacs distributed along its course, would give a curve characterized by a less pronounced initial decline, and a more uniform distribution of irregularities.

As in the preceding experiment, it was obviously not easy to correlate efficiency with any one abstracted activity. Some of the simplest mental operations seemed to have involved in them a rather complex type of mental organization.

D. EXPERIMENT III

The results of Experiments I and II had indicated and emphasized an apparently paradoxical behavior of the rational aspect of the learning process. The fact had been made evident in every introspection that the subject employed in his learning, not a number of isolated activities, such as imagery, discrimination, and others, but a more essentially complex type of reaction. Sensory discrimination had involved in it, for instance, imaginal and conceptional factors. Yet for all this complexity of the subjective aspect of the learning, the actual attempts at systematic reasoning were crude in the extreme, as measured by the simplicity of the problems when presented visually. It was thought not only desirable but necessary to conduct an experiment especially designed to emphasize the ability of the subject to think coherently and systematically, or to reason. Accordingly, Experiment III was conducted with this object in mind.

In order to control this special phase of the learner's activity for the purposes of a more exact investigation, two conditions were observed in the experiment. (I) The subject was instructed to take an overtly rational, thinking, reasoning attitude towards his learning, even if he became convinced that such a procedure did not count towards the greatest efficiency. In the

preceding tests, it will be remembered, he was permitted to take any attitude he saw fit. (II) Two mazes were built, which in addition to offering difficulties similar to those encountered before, presented special formation designed to elicit the maximum amount of reasoning.

1. Apparatus

(*a*) The mazes employed were of the pencil variety. For this experiment, and for future investigation, the writer designed a maze base, upon which any alteration in maze pattern could easily be made. Upon the upper surface of a solid oak base, 14½ by 20 inches in size and 1½ inch thick, two series of parallel grooves were cut, extending from side to side and from end to end, so that they intersected at right angles, and cut the upper surface up into a complete checker-board. The grooves were uniformly ⅛ inch in thickness, ½ inch deep, and ½ inch apart. Into them were inserted steel strips to serve as the sides of the maze paths, and between these strips brass flooring was laid. With an assorted number of brass and steel strips, any desirable combination of path sequences could be easily constructed. For the open space built into maze M, (see diagram, Fig. 12, and description) a solid brass plate, of the same thickness as the flooring, was laid. The exit of this maze was in the interior, at the end of a blind passage. An electric buzzer was used to inform the subject when he had attained it. The brass flooring in this passage was cut off so that it lacked 1½ inches from extending to the end wall, and the floor was continued by a thinner strip of steel, slightly raised above the wood base, and free at its outer end, so that pressure upon it made an electric contact with a wire run through the base of the maze, and started the buzzer. Two mazes, L and M, were constructed with this apparatus, and used in Experiment III.

(*b*) *Object of the designs of the two mazes:* Maze L. The pattern of the path formations in this maze was elaborated to present difficulties by way of the similarity of two different paths. Similarity in the mazes previously used had made discrimination extremely difficult. In maze L it was attempted to arrange the

paths in such a manner that this difficulty could be overcome by a relative reliance upon reasoning processes, as over against a trial and error method. [See Figure 11.]

The object of the experiment in brief was this: Two paths, A and B (in maze L), were of sufficient relative length to set them off as distinct land-marks for the learner, but since they

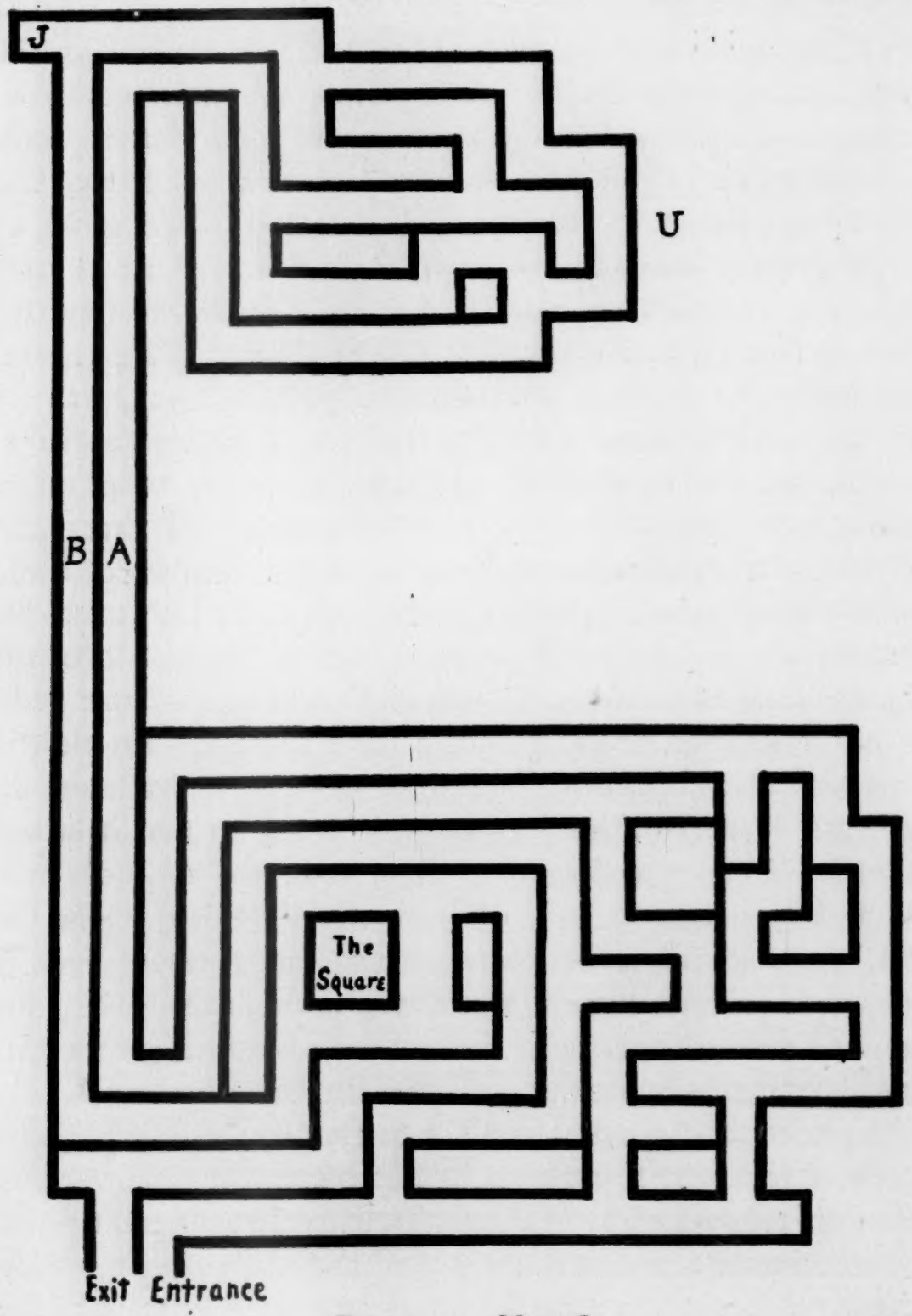

FIGURE 11. Maze L.

were similar in position, and in their respective turns at either end, the difficulty would be in ascertaining whether they were really two paths or one. Efficient learning, however, depended upon the subject's ability to determine this point: if from the lower part of the maze only one long path ascended to a cul-de-sac in the upper part of the maze, then it was useless for the subject to traverse this path, since he had to return by it. If there were two paths, there was the possibility that both were sections of the true path (as was actually the case).

It was obvious that each subject would: (1) raise this issue as just formulated, or (2), would assume without question on the start that there was but one path, only to be disillusioned later, or (3), would perceive on the first trial that there were really two paths. It was correctly assumed by the experimenter that one of the options indicated under (1) or (2) would characterize the learning of the majority of the subjects. As a matter of fact, only two of them saw from the start that there were two paths, and accordingly, no special difficulty presented itself to these two.

The two paths were parallel, and so alike in length, that discrimination on this score was found to be practically impossible. At the top, the three turns and one cul-de-sac leading off from the paths were similar; at the lower end, both turned to the right, then up, then right, with an option on the last turn. One distinguishing mark was made. Path B had at its immediate upper extremity a square opening to the left, while A at its top permitted the subject to turn only to the right.

It was assumed that logically a reasoner, in attempting to discriminate or differentiate between two things in any problem, would seek some distinguishing mark. In this case, that mark was put directly on one of the paths. Logically, the subject could formulate the problem as follows: "If there are really two paths, the possibility is that one of them presents some point of difference from the other. This distinguishing sign is to be sought, first in the path itself, and next, in the respective sequences of turns at either end."

Maze M. In designing this maze [Fig. 12] the experimenter

was prompted primarily by the fact brought out in the "Mouse-trap," where the controlling *idea* that the exit was to the outside of the maze distinctly prolonged the learning of some of the subjects. In maze M the exit was at the place marked × and the subject was informed when he had reached it by the fact that a buzzer was sounded. He was given none of this information however, at the beginning of the first trial. Once again

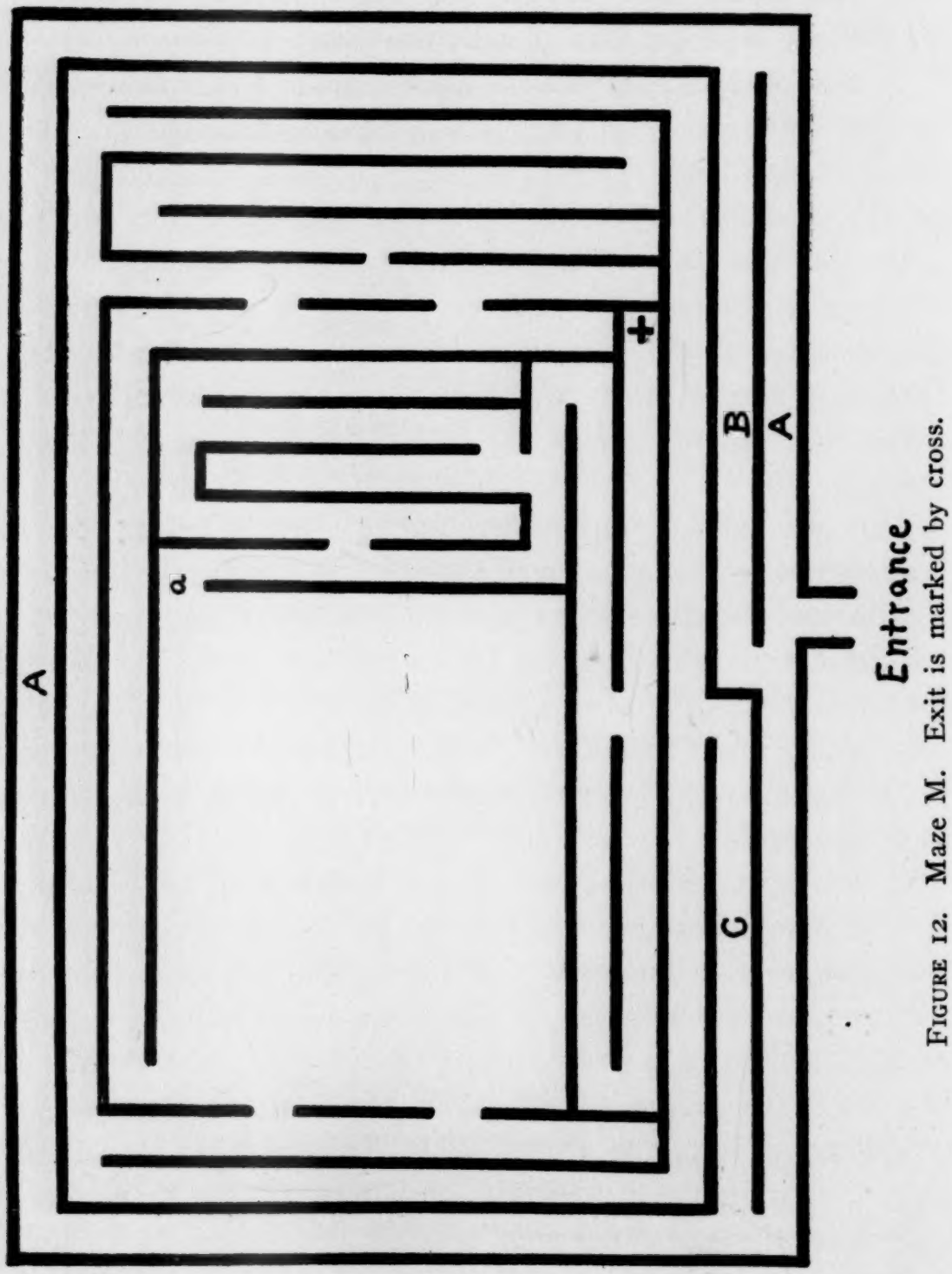

FIGURE 12. Maze M. Exit is marked by cross.

we attempted to give the subject a cue which could be reacted upon in a reasoning way. Path A completely encircled the maze, and brought the subject back to the entrance. Since it offered no other opening to the outside, the exit must be somewhere within the maze.

It was assumed that most of the subjects would make the tour of path A in the first trial. As a matter of fact, all of them did. Since they were asked to use a rational attitude, to keep themselves alert for material to think about, it was thought that such a formation would offer the necessary data.

Two additional points were in mind in designing both mazes: (a) Several cul-de-sacs, like those in the park maze, represented deviations from the typical cul-de-sac formation, such as that found in the first maze we employed. It was desired to study the reaction the subject would make to a new situation, under the new instructions, and to determine whether or not new constructions deterred the learning. (2) The subject was asked to learn the shortest route. As a separate problem, it was desired to ascertain the manner in which the subject could prove that the path he had learned was the shortest.

2. Method

The greatest innovation introduced into the method was the instruction mentioned, that the subject was to do all the thinking and reasoning possible in his learning. Since any given problem often extended over several trials, it was thought best to hold them in succession, with 10-15 minute intervals between trials. The maze was clamped to the table after the manner described in Experiment I. The subject faced the entrance side of each maze, so that U in maze L was called the upper or top side of the maze. The following subjects learned the two mazes: J. R. A., J. W. H., M. H. S. H., M. R. F., S. M. R., C. N., W. S. H., R. B. O.

3. Results

(*a*) *An analysis of the learning method employed in the solution of the different problems presented:* The observation of

the objective behavior gave slight indication only, if any at all, that a different working attitude had been imposed upon the learners. It was practically impossible to tell by the keenest watching what schemes, if any, were being acted upon. The subjects however found that by commenting aloud they were all the more able to formulate their ideas, and in this way, as in the park maze, the observer was given a check on introspective reports and on behavior.

(1) The parallel paths in maze L. The plan of the parallel path arrangement was a source of serious trouble for most of the learners. Maze L proved to be the most difficult maze to learn employed in any of the experimental work. The following summarized accounts give the essential aspects of the methods employed by the learners.

(i) Subject R. B. O. This subject spent two hours and a half, distributed over five trials, in the situation offered by the maze—(the greatest total time spent in learning the first maze, Experiment I, was less than one hour). In trial (I) A was noticed and commented upon as being extremely long when he first ascended it to the U region. Here he became confused, and when he finally found the exit through B, he assumed that there was one path only, leading to a complicated cul-de-sac at its top. No progress was made in trial (II). In (III) he hit upon the idea of two paths, but in an attempt to escape from U he repeatedly came down A, thinking it was the escape path B and he began to doubt his theory. In (IV) the subject went almost directly from A to B through U several times, but conceived the the idea that he was traveling in a circle, and refused to come more than half way down either path. He began to question all the more the possibility of two paths, and by the end of the trial he definitely decided there was but one. Trial (IV) was continued into the next day, as the subject was fatigued at the end of 36 minutes. In this second attempt the subject spent a full 15 minutes trying to find the exit without going up A. He resorted to the scheme of going half way up this path, and then retracing down, because, as he said, "I find the exit after coming *down* this path." Several times he reached the first

turn off A at U but refused to go farther: "I know all about *that* territory, (i.e., knew it was cul-de-sac region) and don't intend to get mixed up in it." He did finally as a last resort explore the region and found himself in J. Then he made the discovery: "There *are* two of them, because the other one doesn't have this notch at the top." The subject had entered J several times before, in the preceding trials, but it had not attracted his attention.

(ii) Subject M. H. S. H. The idea that there were two paths occurred to this subject in (I) but she located the descending path to the right of the ascending one, on the basis of the kinaesthetic feel of arm stretch. By (IV) she was skeptical of her theory of the two paths: "They feel just alike, but sometimes I get out after coming down the long stretch, and sometimes I don't." In (VII) she spent 23 minutes attempting to find the exit without going up A, and on this basis, assumed that after all there were two, and also assumed, without question, that the one to the right was the descending path. By (IX) she was suspicious again: "There really seems to be but one path, and the turns at either end are alike, but sometimes it doesn't lead me to the exit." That is, like the other subjects, she often came down A thinking it was B. In (X) it occurred to her for the first time, in describing the maze in her introspection, that if the ascending path were to the left, the two paths must intersect somewhere in L, since she had found that the exit was to the left of the entrance. In the next trial the subject descended B twice in succession, went around the "Square," and back to U. She was quite sure, however, that she had taken a different descending path each time. Therefore she was certain that A and B intersected in L because they both led into the same region in that vicinity. In answer to a question, she said she could not prove it, or reason it out—there was nothing to reason *on*. But there did not seem to be room at the bottom for two paths so nearly alike, and stretching over so much territory. Therefore there was perhaps only one path after all. In (XIII and XIV) she accidently noticed that a joint in the floor in the lower end of A was more uneven than the one in B. There must be two of

them, therefore. This being settled, trial (XVI) was directed at a more specialized problem: since she had established the identity of the two paths, the question was to tell which she was entering from U—they both felt alike, and she had no way of telling until she reached the bottom. In (XVIII) she discovered J for the first time (she had been repeatedly entering it), found that a similar projection did not mark A, and soon learned to go through this part of the maze without error. She had gradually given up the idea that A was to the right of B.

(iii) Subject M. R. F. The learning of this subject followed very closely that of M. H. S. H. Like her, she raised the question of the possibility of the existence of the two paths in the first trial, and similarly, she thought that the ascending path was to the left of the descending path. This suggested at once however, the two must intersect somewhere at the bottom, since she was sure of the correct relationship of exit and entrance. The subject resolved to perfect the route she had learned before she attempted a study of the situation. By (VI) she had the path fairly well learned, and in this trial also she discovered that J, which she had noticed before, was at the top of B only. This landmark she retained as a cue to tell her on which path she was descending. The subject finally decided that she had misjudged the position of the two paths.

(iv) Subject J. R. A. This subject in his first trial ascended and descended A several times before finding B. He immediately assumed, at the close of the trial, that the two paths existed, because one got him out and the other did not. He also correctly assumed that the return path was the outer one, because it seemed to extend farther up than path A. The rest of the learning presented no serious difficulty to the subject.

(v) Subject C. N. This learner believed after the first trial that one long path ascended to a cul-de-sac territory at the top of the maze, and that it was not necessary to go up this path at all. Most of trial (II) was spent in an effort to find a shorter cut to the exit, but after 20 minutes endeavor in this direction, she decided to try the possibility of the long path. In doing so she discovered J, remembered that she had found it in coming up, and concluded that there were two paths.

Of the other two subjects, the reports of J. W. H. follow those of J. R. A., and the account of W. S. H. is similar to that of the subject just described.

(2) The location of the exit of maze M. The discovery of the inner exit of this maze was practically a matter of accident, as it was in the case of the park maze. M. R. F. in her first trial directly made the circuit of the outside path A several times, in one of which she kept consistently to the outside wall. Although she recognized the nature of the path, as leading her back to the entrance, and although she had the idea rather definitely in mind of finding the exit somewhere on the outside of the maze, the fact that it could not be there did not suggest itself. Her motive, when she did finally approach the interior, was to get *off* this path. She reports however a vague and non-focal state of questioning *how* the surrounding path would affect the rest of the maze.

J. W. H. reports that he did wonder vaguely about the exit after he had made the circuit of A. He did not formulate this into a definite question however. He had conceived of the electric wiring as a device to mark cul-de-sacs, and did not connect it with the exit.

J. R. A. stated that his definite working scheme of making all the right turns tended to exclude questionings about the exit. He too went around A, sticking closely to the outside, without perceiving that the exit must be within. This report is an exact duplicate of the testimony of the same subject in the "Mouse-trap."

No subject got the suggestion of the exit after encircling the maze, although all of them did so in the first trial before they located it.

(3) The perception of new formations in the mazes. Conclusive evidence had been offered in the park introspections in the case of R. B. O. with x and y, and with the other subjects in regard to the exit, to indicate that a novel arrangement of paths or cul-de-sacs, not only taxed the ability of the subject to interpret new situations, but was directly the cause of a delay in the learning. Each subject applied some concept to the new

kinaesthetic and cutaneous experiences: the one that gave the most immediate and satisfactory meaning to the experiences was accepted. Such conceptions proved to be inadequate quite often, from the point of view of practical results.

Subject S. M. R. in maze L offered an instance of such an inadequate interpretation, in her idea of the "Square." [Fig. 13.]

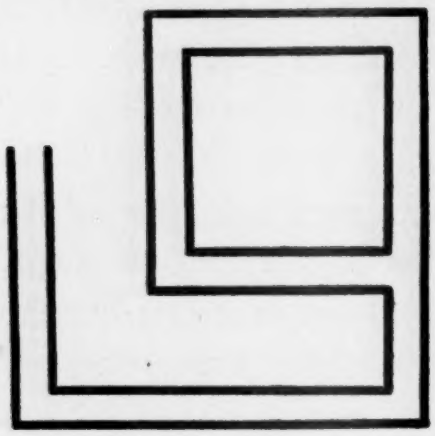

FIGURE 13. The "Square" of S. M. R.

For a full period of 20 minutes in trial I she refused to come down path B, because of the fact that the first time she had done so she went directly around the square and up B, and conceived the situation to be as she represented in her drawing. As was the case with so many conceptions concerning the maze, it was a matter of assuming a situation without question, rather than a process of formulating an option, or criticizing the conception. An example of this was brought out in Experiment I, in which the subjects so many times went to a turn in the true path, and retraced, thinking it was the blind ending of a cul-de-sac.

About half the subjects in their first experiences with the "Square" interpreted it as did S. M. R., but they discovered their mistake before the idea resulted in serious harm.

The record of this same subject presents another instance of uncritical judgment of maze formations in maze M. Early in trial (1) she got into the vicinity of the exit, and conceived the whole area immediately to be cul-de-sac territory. She refused for a long time to enter door *a* because, having located it as the entrance to that region, she said: "Anybody ought to have sense enough to avoid a place like that." This conception, after she had explored thoroughly the possibilities of the surrounding path A, delayed her reaching the exit for a full half hour.

Several subjects in maze M started to the right and came back on B to regain A, in the same way that W. H. S. made 11-12 a

part of the true route in the "Mouse-trap." They accidently discovered sooner or later the nature of the paths.

The cul-de-sacs to the immediate right of the open area in maze M proved to be the most difficult situation to formulate in the maze. The open space itself was peculiar without being complex, and the one thing that made the path easy to learn.

The general result may be summed up in the statement that new situations retarded the learning, unless they were so simple and distinct that they afforded definite cues for orientation, in which cases they facilitated the learning.

(4) The shortest path. The discovery of the shortest path proved to be a matter of difficulty to only two of the subjects. The others, after having once learned to turn left on C, easily learned to enter the open space through the upper left hand area and go diagonally across it. The special possibilities as to relative lengths in general were perceived, as a matter of sensory discrimination, without effort.

M. R. F., however, learned the route as turning to the right on C, then up, and across the top of the maze to the left on the corresponding path. Her discovery of the left side route was purely accidental according to her reports, and was the result of going too far to the left in one trial as she was making this trip, and coming back to the entrance. W. S. H. did not learn the shortest path from the open area to the exit until after he had habitually turned up after leaving it, and had come down the path directly over door *a*. His discovery was accidental, and similar to that of M. R. F.

(5) The nature of the attitude employed in Experiment III. The subjects were unanimous in their statements that the method employed, in spite of heroic attempts to follow the instructions given, was not materially different from that employed in the other mazes. The nature of the type of reasoning they found it possible to do was practically the same as that indulged in when they were left to their own method. The common statement was that they had nothing to reason *on*. The data had to be acquired by trial and error, and the significant discoveries were made in such hit or miss performances.

They did assume an attitude, somewhat forced and artificial, differing slightly from their natural method of attack. This was found to consist in (1) an attempt to 'think-out' certain possibilities by way of theory or conjecture, or to follow a systematic method of exploration. Thus W. S. H., maze L (I), speculated as to which side of the maze the exit might be located. Thus J. R. A. and others followed one side of the path, exploring all its possibilities first. (2) A second characteristic of the process was the more acute attention paid to experiences and cues. This attention was concerned at times with a definite object: several of the subjects, after they had formulated the difficulty in maze L, were overtly on the lookout for distinguishing cues. What they did not do was to search for these cues in a systematic manner. This was practically an impossible task, so they reported, since the major part of their attention had to concern itself with immediate orientation, and since also they were forced to stay in the maze paths—had they been permitted to jump from one section to another, more systematic exploration might have been possible. The two distinctions given were relative only: it was a process of slightly more emphasis upon methods that all of the subjects employed, and which they could not help employing.

(*b*) *The objective results:* The sudden decrease in the time and errors in the 2-5 trials indicate without exception, in maze L, the period in which the nature of the two paths had been discovered. The extended continuation of errors resulted from the fact that the rest of the maze still offered a series of minor problems, in the shape of small cul-de-sacs, easy to escape from but difficult to avoid. The explanation given in the account of the objective records in Experiment III applies without exception to the records from this maze. The same type of abrupt decrease also characterized the results from maze M, and the fact that the time and error curve based on it is slightly more irregular finds sufficient explanation in the fact that the maze itself was more complex. The stage in which the subject learned to avoid the entire right part of the maze is marked by the fall of the curves. The open area in this maze undoubtedly saved it from being more difficult than maze L, the most difficult one we designed.

Subject	J. R. A.		C. N.		M. H. S. H		M. R. F.		W. S. H.		J. W. H.		S. M. R.		R. B. O.	
No. of trial	Time	Errors	T	E	T	E	T	E	T	E	T	E	T	E	T	E
1	10′ 57″	148	54′ 40″	427	16′ 45″	188	5′ 10″	33	38′ 40″	447	8′ 30″	103	1 hr. 12′ 24″	565	39′ 40″	435
2	9 56	130	20 20	194	6 52	67	2 37	38	13 10	295	7 38	98	5 50	30	6 45	184
3	7 16	67	3 37	50	3 24	25	2 54	20	12 10	150	5 10	75	6 45	72	48 45	695
4	8 05	113	44	5	5 32	49	2 46	20	1 13	12	2 30	35	2 51	30	36 37	600
5	30	4	47	0	1 00	9	1 09	9	2 20	24	16	2	2 06	4	18 36	175
6	29	0	34	3	59	3	1 35	10	36	10	14 37	198	1 10	4	5 75	75
7	30	1	40	0	4 33	23	3 07	29	27	1	1 13	9	1 26	7	3 07	62
8	35	8	30	2	2 07	27	2 04	7	22	0	22	2	59	2	4 37	59
9	20	1	30	2	2 47	18	2 33	16	27	3	41	1	44	2	2 57	13
10	47	9	40	0	1 27	16	1 32	9	37	1	34	2	45	1	2 32	20
11	20	0	34	0	3 28	34	1 25	20	30	2	39	0	46	0	2 51	2
12	18	1	32	2	5 16	83	47	5	42	2	34	0	1 20	13	44	13
13	1 14	30	27	2	4 48	40	40	5	36	0	30	0	40	1	26	4
14	20	1	33	0	5 56	64	58	17	47	5			55	6	29	1
15	23	1	35	1	5 26	92	35	0	37	1			40	0	24	0
16	37	12	27	0	3 14	39	38	3	24	0			40	1	26	0
17	26	0	35	2	9 45	118	37	2	21	0			42	10	29	3
18	25	0	40	2	1 27	2	30	4	24	0			30	2	29	0
19	24	0	37	8	1 04	0	27	3	7 14	110			42	2	30	0
20	3 50	70	30	0	1 07	1	22	1					32	1	30	4
21			25	2	56	0	26	1					44	0	19	0
22			40	2	50	0	26	6					39	2	17	0
23			37	0	50	0	21	1					44	8	28	10
24			25	0	44	0	22	2					47	6	22	5
25			27	0	1 23	14	42	8					32	0	20	5
26							24	0					47	7	25	3
27							22	22					35	0	25	3
28							24	1					30	0	25	5
29							21	1					30	0	25	4
30							18	0					25	0	22	0
31							17	0					1 16	15	32	13
32							3 50	30							(Learned at Trial 57)	
Total	47′ 32″	636	1 hr. 37′21″	809	1 hr. 30′59″	912	41′ 40″	317	1 hr. 9′33″	1039	43′ 48″	525	1 hr. 49′ 6″	791	4 hr. 34′ 35″	2455
Average	2′ 22.6″	31.8	3′44.6″	31.1	3′47.4″	38	1′ 18.1″	9.0	4′11.2″	5.46	3′ 22.2″	40.4	3′ 32.4″	26.4	4′1.1″	56.8

TABLE 1.—Time and Error record, Experiment III, Maze L. Results from each trial, up to and including Trial 32, are given. Totals and averages are computed from the complete records.

Subject	J. R. A.		C. N.		M. H. S. H.		M. R. F.		W. S. H.		J. W. H.		S. M. R.		R. B. O.	
No. of trial	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E
1	3′ 26″	36	11′ 45″	73	7′ 37″	47	7′ 12″	58	8′ 11″	35	21′ 35″	147	1 hr. 4′ 49″	490	11′ 5″	98
2	1 38	16	2 35	28	2 33	34	1 00	9	2 14	38	50	3	1 10	5	33	0
3	41	10	49	10	1 57	15	1 02	8	1 55	14	31	0	2 47	28	27	4
4	1 38	18	1 31	14	50	17	45	5	5 21	56	13	0	50	10	27	4
5	2 35	28	2 42	27	50	7	45	5	5 21	56	13	0	52	5	52	8
6	16 40	60	1	20	1 05	8	25	6	3 07	23	9	0	37	5	22	4
7	48	5	58	8	50	5	25	6	3 38	30	10	0	30	3	15	1
8	1 15	9	50	10	51	5	25	5	3 12	39			29	3	16	1
9	3 42	30	45	6	34	4	17	4	5 58	63			30	5	15	0
10	29	2	52	6	35	4	20	4	59	6			24	3	13	0
11	33	2	1 24	13	12	15	15	4	48	6			20	4	12	0
12	17	0	33	6	2 19	23	17	4	34	6			21	4		
13	15	0	33	6	47	8	18	5	50	4			1 20	20		
14	15	0	30	6	1 12	8	1 00	11	50	4			39	12		
15			1 50	18	42	4	15	3	1 48	14			34	4		
16			30	2	1 04	9	15	3	2 13	17			25	6		
17			47	3	29	4	27	5	1 32	8			1 00	7		
18			2 14	27	30	4	29	6	30	0			35	7		
19			1 10	10	1 17	19	18	3	6 03	87			27	?		
20			27	2	27	4	17	3	37	0			31	2		
21			27	2	27	4	14	3	31	0			42	10		
22			30	2	25	4	2 00	19	27	0			20	0		
23			53	8	1 00	10	3 29	20					44	12		
24			40	9	1 36	20	22	0					24	2		
25			29	2	27	2	20	0					18	1		
26			24	2	52	10	15	0					12	2		
27			25	2	2 37	26							34	7		
28			42	2	1 47	26							50	7		
29			30	2	2 05	20							17	0		
30			58	3	36	2							15	0		
31			55	5	47	3							15	0		
32			1 15	12	47	3										
33			45	5	39	3										
34			57	7	53	5										
35			43	3	32	0										
36			(Learned at		3 13	0										
37			Trial 47)		20 12	0										
Total	34′ 12″	216	44′ 38″	351	1 hr. 5′50″	376	23′ 7″	199	52′ 35″	426	25′ 8″	160	hr. 24′ 1″	666	14′30″	116
Average	6′26.6″	16.6	1′16.5″	10.3	1′49.7″	10.4	53′ 3″	7.7	2′ 23.4″	21	3′ 35.4″	22.9	2′ 42.6″	21.5	1′ 27″	11.6

TABLE 2.—Time and Error record, Experiment III, Maze M. Results from each trial up to Trial 37 are given. Totals and averages computed from complete records.

The last trial for several subjects, after the maze had been run three times without error, shows a sudden increase in time and errors. This was occasioned by the fact that many of them chose to perfect their route first, and then explore for a possible path, in compliance with the criterion established for learning. The last trials in such cases represent the time and exploration necessary to satisfy the subject that no shorter path existed.

E. EXPERIMENT IV

The reports from the preceding experiments were unambiguous to the effect that the different attitudes attempted towards learning did not involve actual differences in method. The assuming of a reasoning point of view carried with it a more evident play of ideas, but these ideas as manipulated by the learner did not directly solve maze problems. The results suggested the possibility that the conditions of the learning task made only one method possible, or at the most permitted deviations from this method. The evidence on this point was not conclusive, however, and an experiment was designed to bring out the variations possible.

1. Apparatus and Method

(*a*) Three similar pencil mazes were used in Experiment IV, one of which is shown in the diagram, Figure 14. The paths, ¼ inch wide, were cut through brass plates, 8 inches by 10 inches in size, and 3/16 inch thick. The mazes could thus be turned over and be used mirror fashion. The exit and entrance ends of the paths did not lead out of the mazes, but terminated blindly, like cul-de-sacs. To mark the exit, a brass wedge, fitting closely into the blind end of the path, acted as an inclined plane, and carried the pencil out of the maze, so that the subject knew immediately when he had completed the trial. The wedge could be placed at the end of any blind passage, and thus the exit as well as the entrance of the maze was variable. A wood base, covered by a plate of glass ¼ inch greater in length and breadth than the maze, was used as its support. Four strips of brass, of the same thickness as the maze, formed the border of the top of the base. They enclosed a rectangle slightly larger than

the maze itself, and thus allowed it to fit tightly upon the glass, upon which a sheet of paper could be placed for the purpose of preserving a graph. In addition to holding the glass, the brass border kept the maze firmly in place. The apparatus was easily clamped to the table.

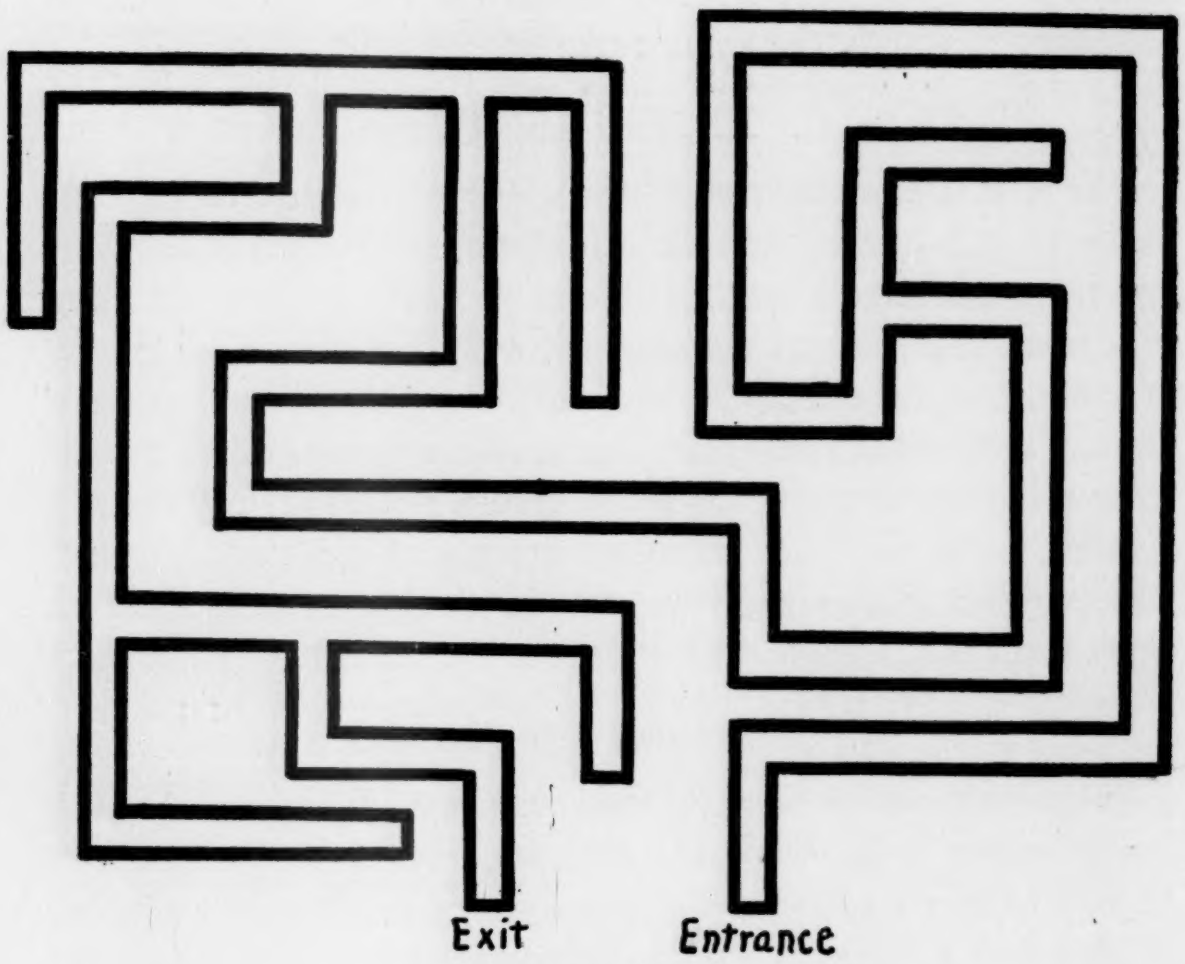

FIGURE 14. Maze I b.

(*b*) *Method:* The subject was asked to learn three mazes, in successive trials, each maze at a different sitting. He was instructed to take toward each a separate and characteristic attitude, which was defined and explained as follows:

(1) His "Natural" attitude. The directions were identical with those given in Experiments I and II.

(2) An attitude of "Conscious Trial and Error." The learner was asked to make the affair as conscious as possible, to attend to, discriminate, and remember paths, but not to reason, or speculate, or indulge in ideational activity not directly concerned with the motor processes to be employed.

(3) An attitude and working method of "Surplus Activity." He was instructed to move as rapidly in the maze as he was able. He was to make no *special* conscious effort, save that necessarily involved in maintaining the speed called for. Since the distraction tests mentioned in Experiment I had convinced us that complete distraction of the attention was impossible, the subject was not asked to concentrate upon some extraneous topic—that is, he was allowed to employ as much consciousness in the learning as the actual speed conditions permitted.

The point was emphasized that a premium was placed upon efficient learning only in as far as it was accomplished in terms of the directions given. Several subjects had stated in Experiment III that the rational attitude was not conducive to the best learning, and it was made plain that objective results were to be sacrificed for the attitude desired.

In designing the mazes, it was attempted to equate them in the matter of complexity. In order, however, to eliminate the factor of the influence of the individual maze pattern, different mazes were offered to each subject for each of the three methods. The mirror form was employed in two cases, but it was arranged that no one subject was given both the maze and its mirror form to learn. At the top of the columns in the tabulative statement [page 98] is found the number indicating the maze used.

The subjects in this experiment were J. R. A., J. W. H., M. H. S. H., M. R. F., C. N., W. S. H., and R. B. O.

2. Results

(*a*) *Reports of the different subjects on method:* The subjects were asked at the close of the experiment to write a detailed introspective analysis, based on a comparison of different methods used in all the mazes they had learned, in this and in the preceding experiments. The essential points of these analyses, expressed as far as possible in the subjects' own terms, are as follows:

(1) Subject M. R. F. The method employed in the "surplus activity" learning was somewhat different from that used with the other mazes. This was the result of the unnatural speed re-

quested in the performance, which interfered with the fixing of associations, partly by the rapid shifting of attention, and partly by the distracting effects of the disagreeable affective state, and the actual strain and fatigue involved. Because of this, segments of the maze were learned as a hand-motor coördination, without conscious control.

These segments, however, were those in which little opportunity for error was present. In times of difficulty such a method was inadequate, and the crucial turns were figured out by essentially the same method used in all the other mazes. The solution was delayed, however, by the conditions imposed.

The attitude taken in the other mazes presented little variation in learning method. Where reason was requested, cues were followed up a little more consciously, and in the intervals between trials, the problems were studied a little more.

On the whole, there was sufficient similarity between the different methods to warrant their being considered as phases of one learning activity, but the "surplus" method represented the most pronounced divergence from the regular procedure.

(2) Subject J. W. H. There are two methods possible by which a maze may be learned, but they are different only in the relative emphasis placed upon common factors. The first was represented in the "speed" maze, the second in all the others. Both involved discrimination and memory, but in the second instance this is more deliberate, more overt. It involves a more conscious attention on cues, and often conscious exploration to find these cues. More emphasis is placed upon the constructing and following out of a visual diagram. In the "surplus activity" maze, little emphasis was laid on the visual element—motor imagery was practically the only type used. J. W. H. was able to describe the true paths in all the mazes when learned, but he knew less about the cul-de-sacs in the maze learned by rapid movements than in the other mazes, although he was out of the true path a relatively longer time. This he ascribed to the fact that chance success through surplus activity characterized the learning in this maze, rather than chance success by means of deliberate exploration.

(3) Subject M. H. S. H. This subject finds only one method available in learning mazes. She attempted in the "speed" maze to learn it in motor terms—i.e., by letting each successful trial help establish a habit. She assumed that the true path would be traversed oftener than cul-de-sac paths, and that they would as a consequence be finally eliminated. But her experience proved that this method resulted in false paths becoming incorporated into the true, hence conscious avoidance of cul-de-sac entrances was essential for every maze she learned. The learning by surplus activity approximated unconscious learning more than the other tests, but the methods employed were essentially the same for all the mazes.

(4) Subject W. S. H. also reported that only one method was possible in the actual process of learning to run through a maze without error. The process is one of discriminating and remembering crucial points. Normally, every turn and path is attended to at the start, whether it presents chance for error or not, and those found free from dangerous situations are dropped out from consciousness. In the "surplus activity" learning, he attended only to those crucial regions, as a series of definite problems, when they forced themselves upon his attention. Therefore there was more surplus ideational activity in the rational and natural methods—surplus in the sense that all of it was not absolutely essential to the act of learning.

(5) Subject C. N. This subject made a two-fold distinction of methods on the basis of the voluntary attention paid to cues and suggested ideas when she made the learning a studied one, as over against the type of process represented in the "surplus activity" method, in which, through repetition of errors, the decisive terms were forced upon her consciousness. Her analysis follows rather closely the description given by J. W. H. and W. S. H., since it places rational learning as one extreme method, as opposed to learning by the method of rapid movement. She drew the distinction, however, in terms of the volitional effort attendant upon the one, as contrasted with the other in which the control ideas were forced upon her.

(6) Subject R. B. O. The essential distinction that this sub-

ject's introspection gave him was that apparent to W. S. H. In any rational method of solving maze problems, the attention at first concerns itself with every experience and every suggested cue, although some of them are found afterwards to be non-essential. In the non-rational method, these experiences are not attended to until either a chance success forces some of them upon the consciousness of the learner, or repeated entrance into a cul-de-sac does the same. In such instances, attention to them is necessary and involuntary, and is indispensable for learning.

(*b*) *Summary of the analysis: the nature of the method:* The similarity of the different reports leaves no doubt that to the minds of the subjects the learning under different conditions presents simply phases of the some process. One aspect involves more than the other, of what was variously defined as consciousness, volition, effort.

The different mazes called forth these distinct attitudes only partially. In the original pencil maze, and in the "Mouse-trap," there was a constant, almost periodic, fluctuation between these two extremes. Sometimes helpful cues were obtained with one attitude, sometime with the other. The fluctuations were due to fatigue, or to a shifting opinion as to the values of the two methods, or to the type of local situation in which the subject found himself. The testimony was unambiguous to the effect that in crucial points the *idea* of which way to turn, or not to turn, was necessary. At times the subjects were definitely on the lookout for such ideas, at other times the essential controlling information was suggested to them involuntarily.

Of the two extremes, the one imposed by Experiment III, the other by the "surplus" method, the subjects were in accord in the statement that they were both artificial and futile. Neither was a "natural" method. They could not learn a maze by "reason," neither could they by a technique tending to eliminate the type of consciousness involved in the process—voluntary attention, discrimination, judgment, suggested working ideas, memory. The "natural" method, and the method of "conscious trial and error" were found to be identical, and the latter phrase was accepted as a just characterization of the processes involved, if it

were taken to include something more than a mere passive retention of cues discovered accidentally.

Numerous writers have of late formulated a modification of the conventional antithesis between "trial and error" and "ideational" learning. Ruger[4] mentions the fact that the hit-or-miss method was in evidence with his subjects in their attempts at the solution of puzzles. Colvin, who cites Ruger's results, refers to the trial and error method with human learners, but emphasizes the fact that the learning endeavors made by human beings are not aimless, but are controlled by anticipation of probable results: "When, however, we have reached a higher stage of development, particularly in man, we may assume, as we have already pointed out, that trial and error is something more than a hit-or-miss process through which an adjustment is finally secured. The trial becomes a conscious one, and is self-directed." [5]

Correlating the results of this with the previous experiments, we conclude that, in general, the method of learning was conditioned by the nature of the maze, rather than by the attitude of the learner. In proportion to the extent that the maze was complex, a greater amount of conceptual control and reasoning were called into play. In any simple maze, the method approximated a process of mere trial and error. A certain amount of discriminating and memorizing was necessary, and little opportunity was given for the play of higher processes. *The learner has control over the method to this extent: whether the sum total of these activities is to be represented in one trial, or is to be distributed over a series of trials, is largely a matter of choice.* The indications are that the most efficient distribution is a matter of individual variation. The subject tended to set the pace in the first trial that was to characterize his ensuing trials, and he termed this his "natural" method of learning. The speed demanded in the surplus activity test was evidently too great. The subject was not given time for making or fixing associations. No experi-

[4] Ruger, "The Psychology of Efficiency," Archives of Psychology, June, 1910.

[5] Colvin, "The Learning Process," 1912, p. 23.

ment was attempted to determine the speed below which efficiency would suffer.

In difficult mazes, like the "Mouse-trap," simple memory and discrimination did not suffice to give the variability of behavior necessary in order to discover and retain the location of the exit, and the sequence of paths leading to it. Then, more general and conceptual ideas were employed: their function was to reduce to a minimum the number of trials, or to secure *effective* variability. Thus, had the general scheme of the maze just mentioned been given to the subject before he entered it, the bad records for the first trial would undoubtedly have been cut down. The problem was therefore largely one of ideational learning, and the explanation of the divergencies in the objective results is to be found partly in the fact that different conceptions were formed, of varying degrees of correctness, and that all sorts of predilections entered into the process.

F. THE LEARNING CURVES

In plotting the curves, the percentage method of the elimination of surplus values was adopted. This scheme was used by Carr and Hicks[6] in their paper. It seeks to measure in terms of percentage the rate at which excess or surplus time and errors are reduced to zero. The time not absolutely essential for the traversing of the maze is considered as surplus, and it is found by subtracting from each trial, the shortest time made in any trial. As might be assumed, the shortest time made is usually found in a trial without errors; this is, however, not necessarily the last trial. Since all errors are surplus no similar subtraction is made. After the surplus time has been computed for each trial, the time and error records for the first trial are each given the value of 100 per cent, and with this as a basis, the percentage value of each of the ensuing trials is computed. The curve is then plotted upon the percentage results.

The method has two advantages. (1) It brings the time and error records down to the same base line, in any trial in

[6] *Cf.* Carr and Hicks, Human Reactions in a Maze: Jour. of Animal Behavior, Vol. II, pp. 98-125.

Trial No.	Subject	J. R. A.			J. W. H.			M. H. S. H.		
	Maze	IIa	IIIa	Ia	Ib	IIb	IIIb	IIb	Ia	IIIb
	Method	Nat.	T. & E.	Surp.	Nat.	T. & E.	Surp.	Nat.	T. & E.	Surp
1		1′-17″	5′-12″	1′-30″	3′-45″	2′-06″	1′-17″	1′-24″	-58″	3′24
2		2-27	1-00	-20	-45	-23	1-01	3-38	1-04	-09
3		2-45	-39	-59	-07	-26	-18	2-48	-18	-36
4		-45	-38	-21	-10	-22	-09	2-55	-31	-35
5		-33	-15	1-03	-07	-20	-09	-45	-20	-51
6		-36	-15	-11	-06		-42	1-02	-25	-14
7		-35	-19	-11			-15	-47	-55	-24
8		-33	-26	-29			-26	-25	1-30	1-05
9		1-00	-23	-10			-10	-32	-34	-10
10		-41	-20	-09			4-14	1-04	1-04	-09
11		-14	-14	-19			-16	-48	-45	-13
12		-46	-17	-10			-15	-30	-31	-09
13		-21	-18	-15			-20	-21	-28	-47
14		-17	-21	-16			-15	-51	-52	-15
15		-18	-20	-13			-07	-15	-28	-06
20		-19	-20	-10			-16	-20		-38
25			-30	1-03			-19			-05
30			-13	-08						-05
35			-20	-17						-12
40			-50	-18						-10
45			-20	-14						-24
50			-16	-09						-50
55				-09						-20
60				-13						1-01
65				-20						-15
70				-09						-08
			(Trial 94)	-09				(Trial 126)		-12
	Total	16′ 32″	21′ 14″	24′ 43″	4′ 50″	3′ 37″	11′ 45″	19′ 49″	12′ 24″	50′ 3
	Average	47.7″	22.1″	15.7″	48.3″	43.4″	21.5″	59.4″	41.3″	24.4

TABLE 3.—Time record, Experiment IV, showing results for the first fifteen trials, and for every
in which it does not fall upon a trial number given in the column. Totals and averages are comput

H.		M. R. F.			C. N.			W. S. H.			M. R. F.		
	IIIb	Ia	IIIa	IIb	IIb	Ib	IIIa	Ia	IIa	Ib	IIIb	Ia	IIb
E.	Surp.	Nat.	T. & E.	Surp.	Nat.	T. & E.	Surp.	Nat.	T. & E.	Surp.	Nat.	T. & E.	Surp.
"	3′24″	-22″	-42″	-22″	5′-14″	2′-28″	-18″	-22″	4′-00″	1′-40″	-55″	1′-20	-39″
	-09	1 -50	1 -08	-35	-18	1 -32	-42	-35	-16	-15	2 -40	-21	-23
	-36	1 -40	-20	-29	-27	1 -32	-42	-36	-47	-15	-43	2 -27	-24
	-35	-29	-16	-14	-28	-17	-08	-15	-17	-18	-51	-15	-11
	-51	-17	-15	1 -01	-20	1 -00	-09	-15	-18	-08	-25	-18	-23
	-14	-18	-20	-39	-28	1 -0/	-09	-14	1 -57	-13	-20	-23	-11
	-24	-20	-15	1 -01	-20	-38	-08	-24	-15	-06	-23	-24	-07
	1 -05	-17	-49	-15	-18	-38	-07	-22	-16	-16	-20	-12	-10
	-10	-13	-16	-14	-16	1 -01	-11	-23	-16	-09	-25	-13	-10
	-09	-13	-14	-24	-17	-20	-12	-13	-11	-08	-20	-14	-09
	-13	-12	-25	-12		-16	-12	-10	-11	-09	-16	-10	-09
	-09		-15	-20		-19	-05	-10	-08	-14	-16	-10	-07
	-47		-13	-11		-24	-05	-09	-09	-09	-13	-13	-07
	-15		-13	-14		-20	-06		-09	-09	-13	-10	-08
	-06			-06		-19	-06			-09	-13	-10	-10
	-38			-08		2 -01	-06			-08			-05
	-05			-09			-11			-08			
	-05			15			-08			-09			
	-12			-06			-08			-10			
	-10			-06			-09			-06			
	-24			-15			-08			-06			
	-50			-08			-16						
	-26						-08						
	1 -01						-17						
	-15						-09						
	-08					(Trial 69)	-08						
)	-12												
4″	50′ 33″	6′ 11″	5′ 52″	11′ 09″	8′ 25″	9′ 10″	9′ 00″	4′ 08″	9′ 10″	10′ 38″	8′ 30″	7′ 46″	4′ 11″
3″	24.0″	33.7″	25.1″	13.3″	50.5″	41.4″	9.1″	19.0″	38.5″	11.2″	34.0″	24.5″	11.9″

or every fifth succeeding trial up to No. 70. The number of the last trial is indicated in parentheses in cases
computed from the complete records.

which all surplus values are eliminated. In this way, it simplifies the task of ascertaining the number of perfect or nearly

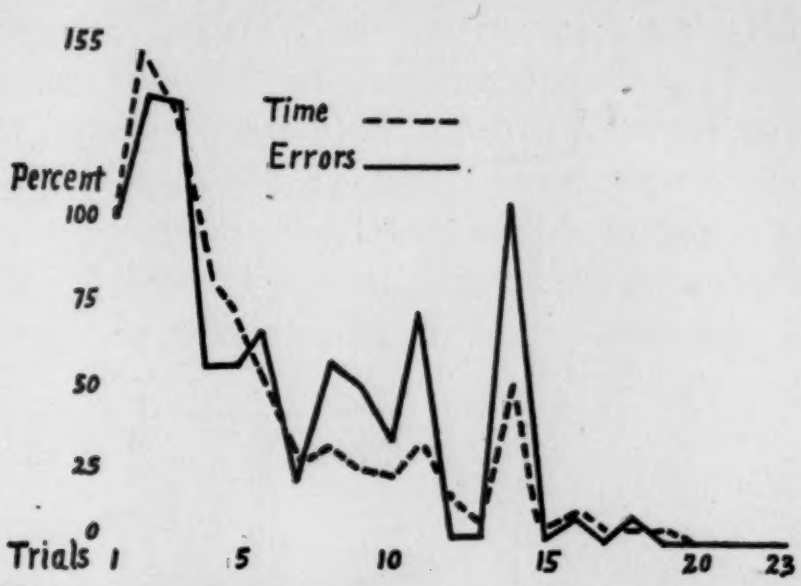

FIGURE 15. Percentage Curve of J. W. H., Normal Maze.

perfect trials represented in the graph. (2) The relation between the time and error curves, i.e., the varying number of errors per unit of time, is readily estimated. For purposes of comparison, two curves of J. W. H. are reproduced, one based on the percentage method, and the other upon absolute time and errors. (Figures 15 and 16.) One disadvantage of the percentage curve is that it is likely to be misleading when the graphs of two or more learners are compared. The records of J. R. A. and M. R. F. (Figures 23 and 24) would seem to suggest that the latter subject learned the "Mouse-trap" with the greater ease. Her time and error results for the first trial were 1 hour, 20′, 56″. and 175, as over against 21′, 37″, and 46 errors for J. R. A. But since the results of the first trial are given the same value for each learner, 100 per cent, the graphs do not afford a ready basis for a comparison of absolute results of the different subjects.

The curves based on the "Mouse-trap" and the Normal maze records were selected for reproduction since they were the two mazes learned without restrictions being imposed upon the learner. The tabular results of the other two experiments however readily suggest what would be the general nature of their curves, if they were actually plotted. Two features of the curves are es-

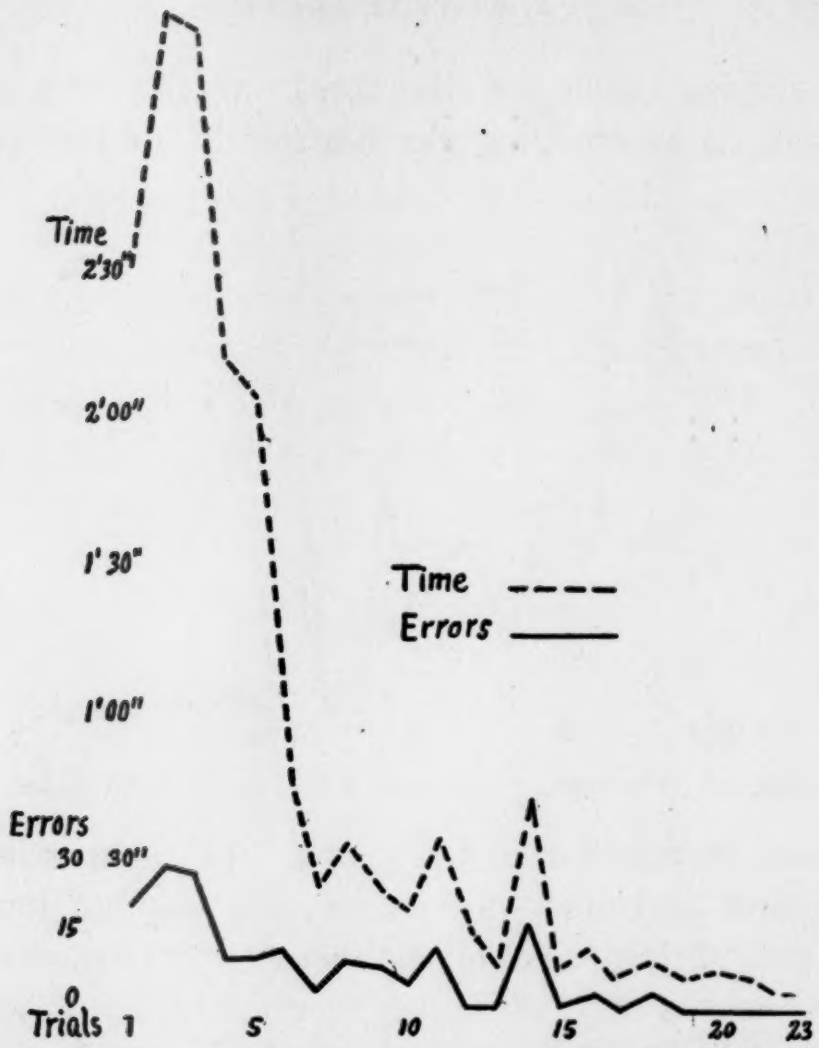

FIGURE 16. Curve of J. W. H., based upon absolute time and error records, Normal Maze. A comparison of this curve with Figure 16 will show the points of similarity and difference in the curves.

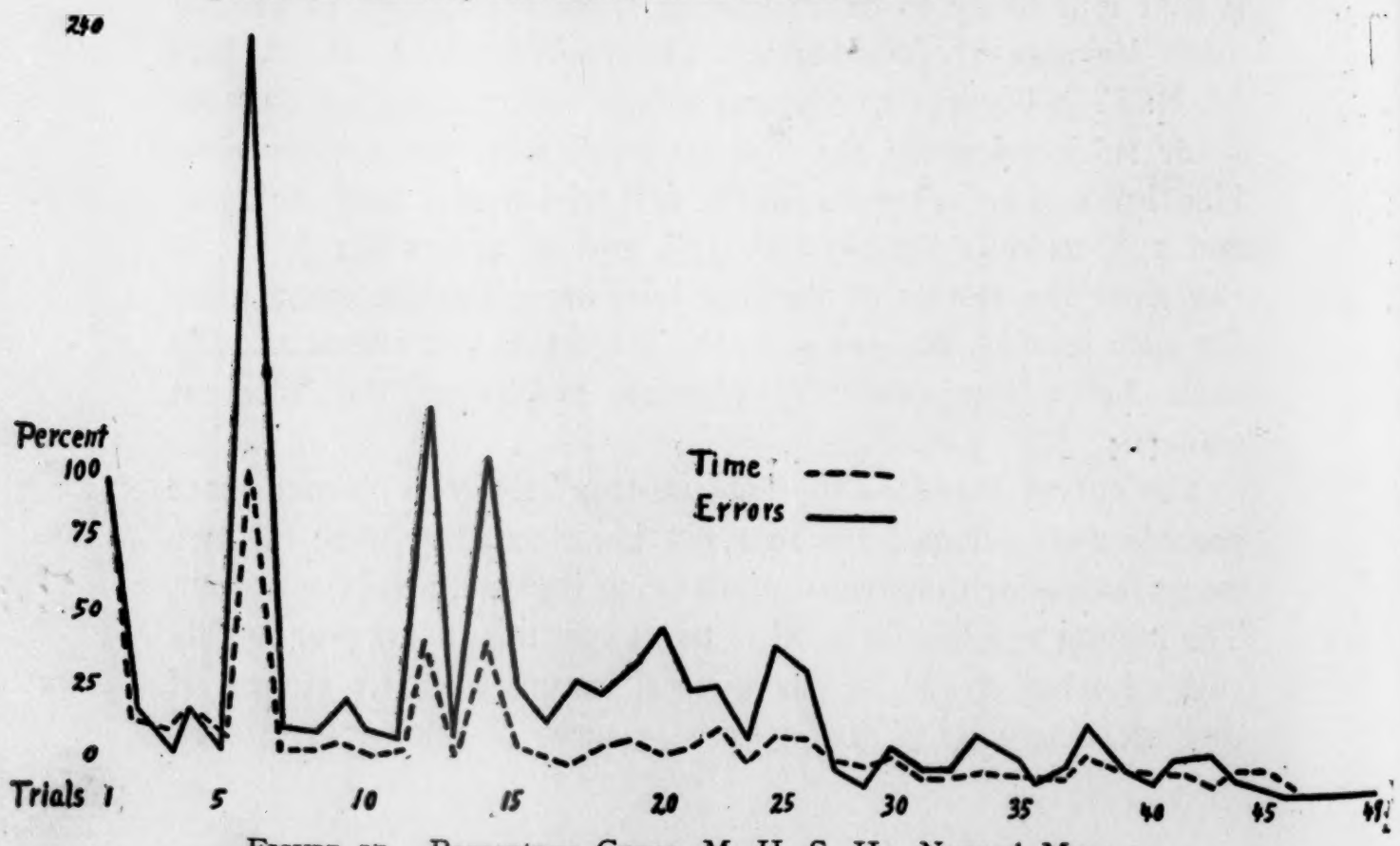

FIGURE 17. Percentage Curve, M. H. S. H. Normal Maze.

pecially prominent: (1) the rapid initial descent; (2) the presence of a marked series of "steeples." The first especially characterizes the "Mouse-trap" curves; the steeples are more in evidence in the curves from the Normal maze.

(1) The conclusion has been urged in a preceding section of the paper that, in as far as there is variation in the learning method, the variation is conditioned largely by the pattern of the maze itself. The results indicate that, on the objective side, there is a corresponding difference in curve characteristics.

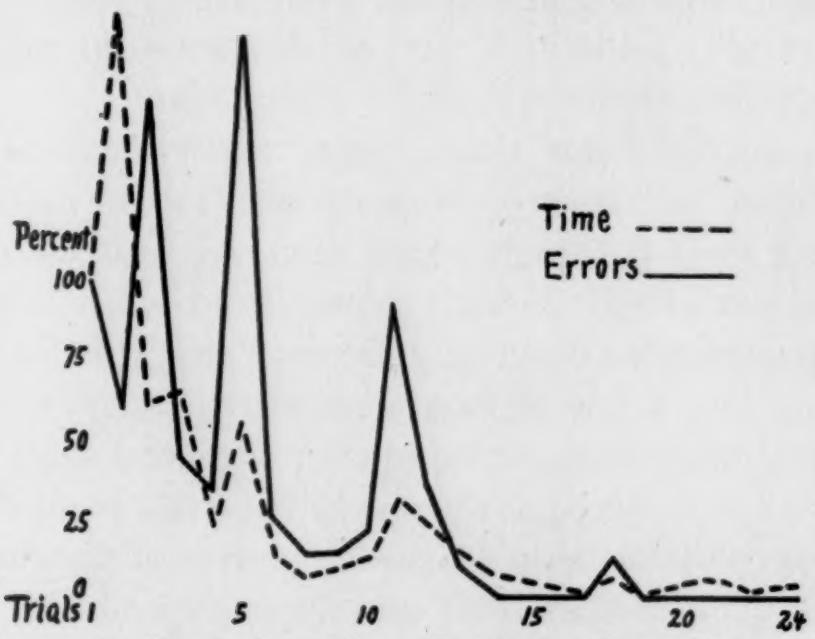

FIGURE 18. Percentage Curve, G. M. F. Normal Maze.

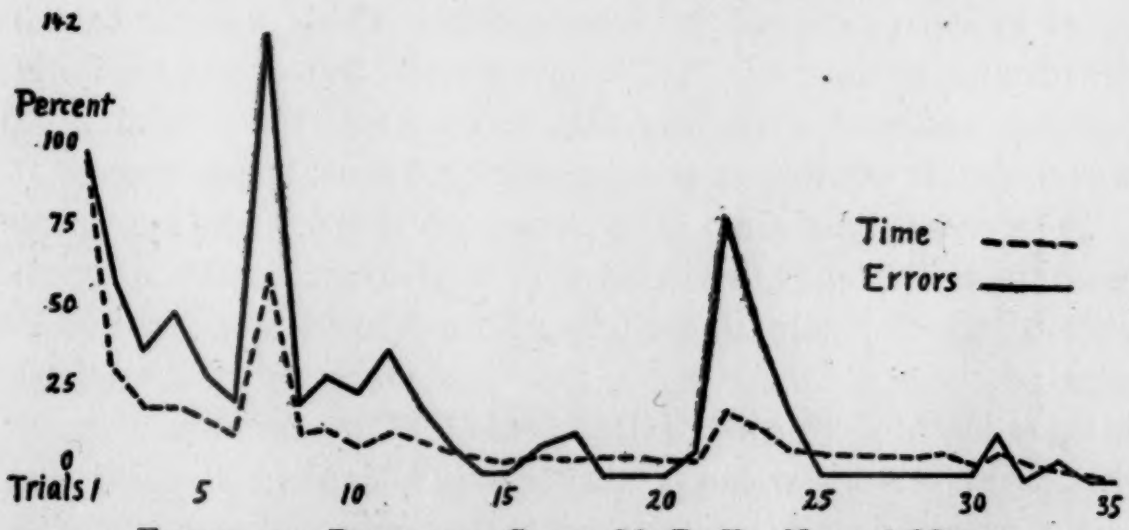

FIGURE 19. Percentage Curve, M. R. F. Normal Maze.

A maze, irrespective of the variable factor of difficulty, may be *complex* in two radically different ways. The path may include a relatively large number of turns, and the individual cul-

de-sacs may be simple, consisting at the most of two or three segments—as, for instance, the "L" form of cul-de-sac. This maze would be difficult in proportion to the number of such blind passages. As opposed to this type, the true path of a maze may be simple, and the number of cul-de-sacs few, but if they happen to be in themselves complex, the situation that is presented to the learner is essentially different from that offered in the kind of maze just described. Of the mazes employed in our investigation, those used in Experiment IV, and sections of some of the other mazes fall under the first class; while the "Mouse-trap," Maze M, the parallel paths in L, and cul-de-sac 6-9 in the first maze used, represent formations of the second class.

Our results indicate that a maze curve tends to show the rapid initial fall in proportion to the extent that the maze involves a short true path with a few very intricate cul-de-sacs. The true path itself is easily remembered when once learned; hence, assuming, as is actually the case, that it is learned in the first trial, only a few trials are required in order to perfect it. Obviously, other things being equal, the general slope of a curve is the more pronounced as the number of trials is cut down. But a complex cul-de-sac either taxes the powers of discrimination to the utmost, or proves to be entirely too formidable for them, and the practical result is that much time and labor is expended in order to learn to *avoid* the false opening. This was the case in the instance of door *a* in the "Mouse-trap." In maze L, the initial problem assumed a slightly different aspect: the crucial thing was to decide whether or not the long path must be traversed.

In a maze consisting of a series of simple cul-de-sacs, the learning effort tends to extend over a prolonged series of trials, each of which results in a slight addition to the detailed knowledge of the route. As in the type just discussed, the emphasis is upon learning to avoid false openings; but there are many of them, and only a few can be mastered in a single trial. The simplicity of each is a guarantee against the subject's becoming hopelessly lost in the path, and in this way unduly prolonging the trial. The records of Experiment IV indicate clearly the curve belonging to this type of maze.

It should be remembered that our results pointed to considerable freedom for the learner in the matter of the distribution of his time. Hence, it is quite conceivable that one could deliberately decide to learn as much of a simple maze as possible

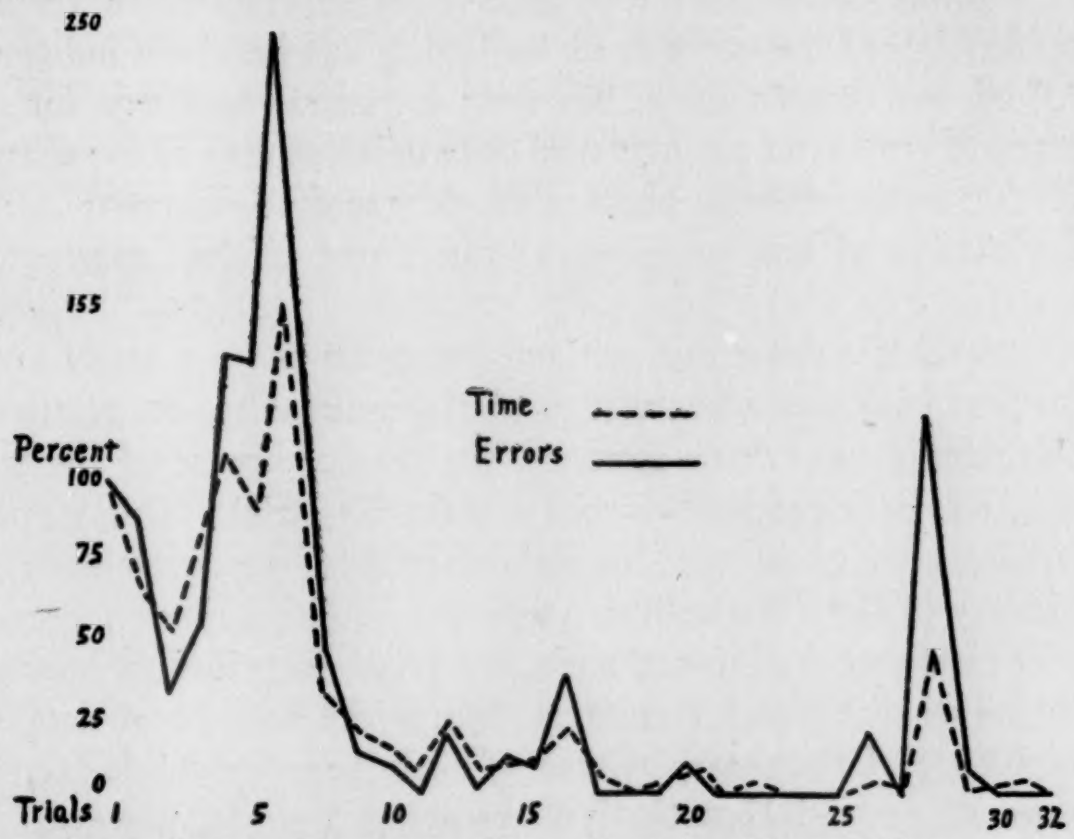

FIGURE 20. Percentage Curve, E. C. P. Normal Maze.

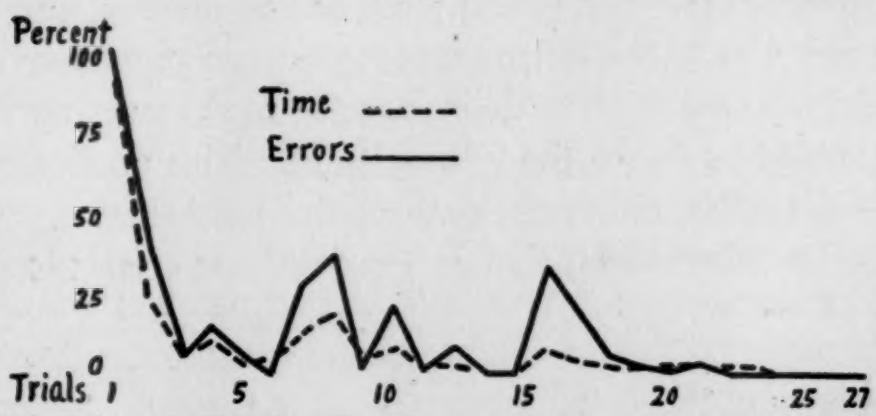

FIGURE 21. Percentage Curve, H. F. A. Normal Maze.

in the first trial, by prolonged exploration. Such a procedure would tend to result in the type of curve that we have just associated with the more complex maze. This method was however not followed by any of our subjects, in the simple mazes, so that it would scarcely seem to be a natural way of learning.

On the other hand, it would be impossible for a learner to distribute his time and errors in such a maze as the "Mouse-trap" in any other way than that shown by our subjects, assuming that the maze presented the same problem to him as to them.

A prime factor that we conceive to be responsible for the sudden fall of the curve at its beginning has just been indicated. All of our records show, however, a general tendency for the curve to drop after the first trial or two, irespective of the scheme of the maze. Hence, another factor must be operative. The explanation of this tendency is to be found in the introspective reports.

The reports show that without exception the net result from the first trial was a knowledge of the general spacial relations. The relation of exit to entrance, the general course of the true path, was acquired by everybody in the first trial. This was especially obvious in the Normal maze, but was sufficiently in evidence in the "Mouse-trap" reports.

The subject had for the second trial, therefore, a skeletal scheme of direction. Assuming that in the absence of detailed knowledge of the maze, he was as likely to enter cul-de-sac 6-9 [page 4] in trial II as in I, in escaping from it, however, in the second trial, this general idea would tend to inhibit him from turning on H. In the first trial, he had no reason to assume that the exit was to the left of this region. As a matter of fact, several subjects testified to their surprise in discovering that the maze extended as far to the left as it did. This applies to every region in the maze, either the path or the cul-de-sac.

It is to be remembered that in the first few trials the learner

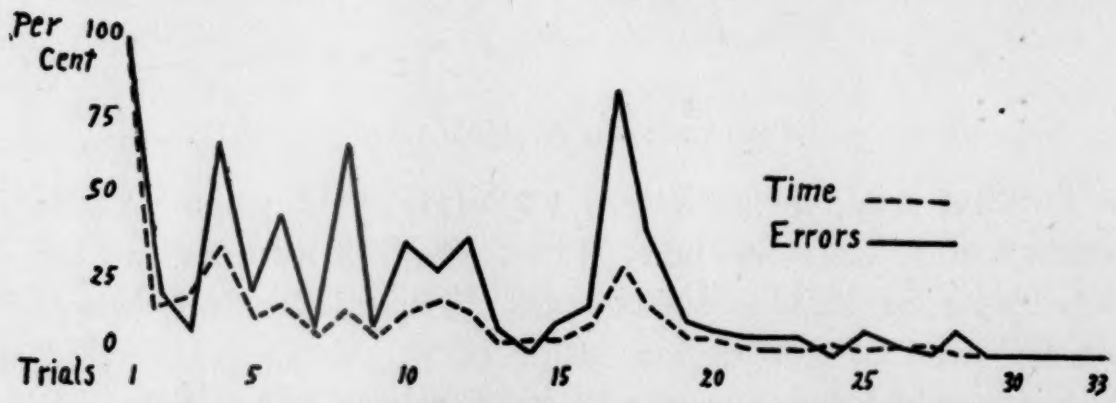

FIGURE 22. Percentage Curve, J. J. T. Normal Maze.

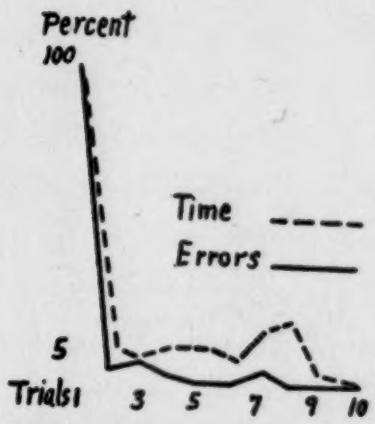

FIGURE 23. Percentage Curve, J. R. A. The "Mouse-trap."

did not recognize H or I as belonging to the true path, as distinguished from 6. The ability to distinguish which of a series of turns had led him into a blind ending was acquired only after more prolonged study of a region. Even a simple situation like 13-14, when the subject entered it for the first time, did not come to him as a cul-de-sac, but as a runway making a right-angled turn. The subject, instead, found himself, after a series of turns, blocked by a blind ending. Hence, in the second trial, his control was the dominant idea of taking any turn which led to the left.

The behavior in the second trial was motivated by this general working scheme, as was also, to a large extent, the third. Specific problems began to be raised in this trial, to be acted upon in the fourth. Since the control for III was practically the same as for II, but more specific and definite, a second decrease in time and error was to be expected; but since the *essential* aspect of the idea had functioned for the second trial, a less pronounced decrease would obviously result. The introspections are in complete accord with these suppositions.

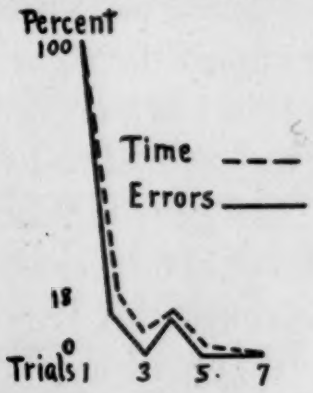

FIGURE 24. Percentage Curve, M. R. F. The "Mouse-trap."

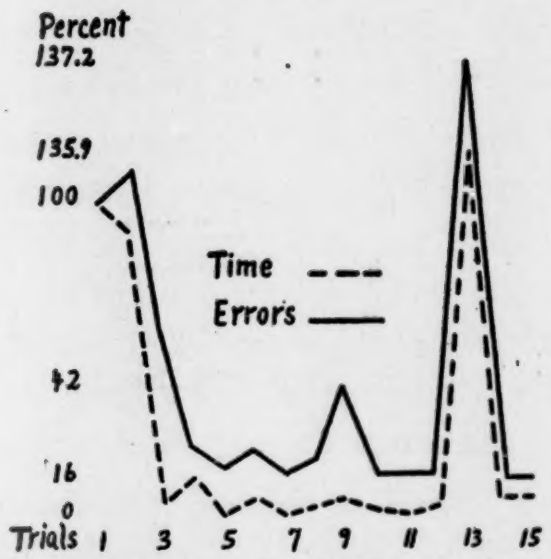

FIGURE 25. Percentage Curve, W. S. H. The "Mouse-trap."

(2) All of the pencil maze curves, and some of those plotted from the park maze records, disclose an irregularity marking the trials III or IV, and a series of fluctuations—the "steeples"—extending over the following half dozen or more trials. There are a number of reasons which account for these irregularities. Some of these may be conveniently grouped together, as constituting a general causal factor.

The general reason why, in the stage of learning represented by the third or fourth trial, and extending throughout the learning, fluctuations should occur, is to be explained by the fact that at this stage the control was rather definitely changed from a general spacial idea to a series of specific control ideas, built up by various factors, each tending to increase temporarily the time and error records. After the third trial, the process of learning the maze resolved itself into a series of individual problems.

Again, the reports from the "Normal" maze indicate the nature of these problems. The learner knew by this time that a rather complex cul-de-sac occupied the right section of the maze. He was interested, therefore, in learning definitely how to avoid it, either by fixing in mind the specific turns in the true path, or the openings in the path. His general scheme had been found inadequate to carry him through this vicinity safely. He was interested, not in working *through* this region, but in traversing it without error. We find reports of the subject's being "hopelessly lost" in this region in the 3-5 trials, that we did not find

in the initial trials. They were lost because their problem had changed, not because their general orientation was less known.

Therefore, at this stage, in ascending path 6, not knowing yet its relation to the rest of the maze, the subject, actuated by a special motive, might: (1) be tempted to explore the region. This being the case, he was as likely to turn into H as to continue on I. A number of errors would result as a consequence. In fact, he would tend to take H rather than I, since his object was to discover the relation of the cul-de-sac to the earlier part of the true path, or the part that had led him into it. (2) The learner might be interested in fixing in memory, or in discriminating in turn the various paths of this portion of the maze. Several of the subjects spent a consderable amount of time in going back and forth between the end of 7 and 9, until the inverted T notion of the situation was established in mind. (3) In the case of being "hopelessly lost" in this region, as the result, sometimes of exploration, sometimes of merely an attempt to get through, a large number of errors were often scored. The subject would resort to an almost pure type of trial and error, in order to find the true path. Even in this, however, he was guided perhaps not completely consciously, not primarily by the general sense of direction, but by the more specific feelings of familiarity and knowledge of this region already acquired. He was more interested in discovering the known part of the true path than he was in finding the exit. Hence, more errors would result when he was lost than in the earlier trials, in the same objective situation. Any of the three procedures just mentioned would tend to raise the curve.

The introspection brought out a number of specific but more or less interrelated explanations of irregularities in the curves during this period of definite maze problems. The first grouping includes those factors intimately involved in an attempt to work out a situation or problem consciously. These factors, or motives for behavior, were: (1) conscious exploration, with the object of studying any particular segment for the purpose of eliminating the non-essential parts of it. (J. J. T. VI, VIII, X, XVII, G. M. F., VI, and all other subjects at times); (2) retracing for

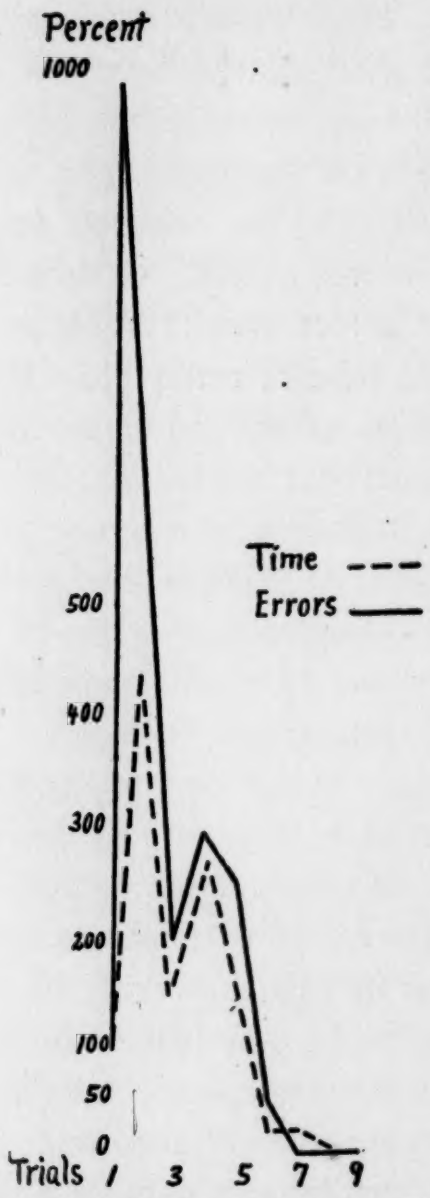

FIGURE 26. Percentage Curve, E. W. J. The "Mouse-trap."

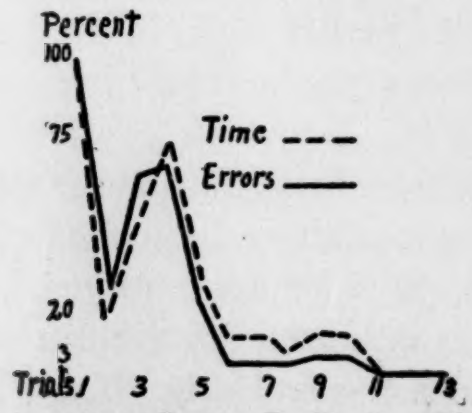

FIGURE 27. Percentage Curve, R. B. O. The "Mouse-trap."

the purpose of fixing in memory a certain segment; (3) misinterpretation of the experiences, incidental to the study of a region. This did not always increase the time and errors. A second group

finds its general explanation in the fact that attention and interest, habit and emotional conditions were in part variable factors. Hence we had reported, (4), distraction of attention, (E. C. P. VII and others), (5) general laxity of attention (M. H. S. H., VI, XII, J. J. T., VIII, M. R. F., XXXI), (6) over-reliance on automatisms, (J. W. H., VIII, XI, XIV, J. J. T., XVII). A third and most common cause of errors was (7) due to the tendency to resort to a trial and error procedure, as a result of fatigue, discouragement, accidentally getting lost, and various conditions. It is not implied that this method necessarily was the cause of more errors than would be the attempt on the part of the subject to maintain a more conscious attitude.

The irregularities occasioned by the development of specific problems were necessarily involved by them. No study of a situation could be possible without costing an expenditure of time, and of errors, under the marking system employed in the experiment. The tax on memory was too great to permit certain regions to be learned without frequent retracing through them.

Increases due to the other factors seemed practically as unavoidable. The demand upon the attention and memory was rather severe during the learning period, and assuming even the possibility of the subject maintaining a constant amount of attention during the trials, the problem of its distribution was a vital one. To the extent to which the subject concerned himself with the attempt to keep in memory a section just learned, throughout the remainder of any trial he must necessarily be somewhat lax in attending to the situations encountered.

The reasons specified account for irregularities; they hardly explain the fact that these irreguliarities graphically should take the form of steeples. Or, in terms of the quantitative results, while they account for a sudden increase in time and errors at any given instant, they do not explain why this was invariably followed by a corresponding decrease in the next trial.

The fact that each new trial meant a "fresh start" was a strong factor tending to safeguard the subject from carrying into any trial the bad effects of the previous one. Accidents in a trial due to laxity of attention, or reliance upon habit, seemed to put

the subject on his guard for the next trial. The emotional effects were as a rule not carried from one trial into the next. At the same time, however, a problem generally extended over a series of trials; and to the extent that no special progress was made in any one trial, the records tended to be similar for the series. Hence the curves show the combined effects of the two factors.

III. SUMMARY OF RESULTS AND CONCLUSIONS

A. The nature of the learning process

1. The human adult in learning a maze employs the conscious processes of discrimination, memory, etc., in order to build up an ideational control. Unconscious learning of segments which represent any degree of complexity is practically impossible.

2. Two chronological stages were in evidence in the conscious part of the learning. The subject was guided in the first few trials by a general scheme of direction, gained when the exit was attained for the first time. He then found that in order to perfect his route a number of separate segments, presenting special problems, must be studied.

3. Difficulties were offered mainly in the form of memory or of analysis and interpretation. A maze whose cul-de-sacs were simple primarily taxed the memory; one in which the formations were intricate called for more active analysis.

4. The immediate reaction upon the maze experience is perceptual in its nature, and simple formations are immediately and easily analyzed. A complex formation, on the other hand, calls for an interpretation of the difficult segment. It is in the elaboration of this interpretation that higher mental activities are elicited.

5. The rational processes reported were unsystematic and seemingly futile. Adequate interpretations were suggested to the learner as the result of prolonged exploration, rather than reasoned out. Cues which logically should be utilized for correct inferences were disregarded, and ideas were acted upon in an uncritical manner until they were proven by trial to be incorrect. The explanation of the meagre attempts at reasoning is to be found in the fact that the learner had no past experience to apply

to the situations, and in the fact that he was unable to select his data—maze paths must be traversed in order.

B. SPECIFIC FUNCTIONS INVOLVED IN THE LEARNING

(a) Sensory discrimination: 1. Sensory discrimination in the pencil mazes was made possible by, (a), the feeling of arm position; (b), the length and direction of arm movement, in any given run-way; (c), the sense of tactual projection, at the point of the pencil.

2. A series of specific tests failed to warrant any assumption of correlation between ability to learn mazes and proficiency in sense discrimination.

3. A number of supplementary tests proved that transference from one set of muscles to another is easily accomplished. That is, the left arm can be used without loss of efficiency after the right arm has been employed in the learning; and wrist and finger movement may be substituted for arm movement.

4. While the physical technique called for in the "Mouse-trap" seemed radically different from that demanded in the pencil mazes, the learning process seemed to be essentially the same. The learning was perceptual and ideational, rather than sensory.

(b) Imagery: 1. The subjects represented a rather inclusive series of image types and combinations. Each individual employed his peculiar image equipment for all mazes.

2. Objective tests purporting to check up reports on imagery were in the main unsuccessful; they did however serve to convince the subject of the accuracy of his introspections on imagery.

3. We were unable to make any correlation between the type or combination of image processes used with efficiency in maze learning. In addition to the absence of obvious correlation, the fact that different subjects used the same form of imagery in different ways made comparison impossible.

4. Some reports were found which indicated that those relying upon kinaesthetic image processes tended to rely more upon motor habit than the other subjects.

(c) Attention and Habit: 1. Attention, in learning any maze,

was distributed in a three-fold way: it was concerned with, (a), the actual experience while traversing any section; (b), the "trail behind"; (c), an anticipation of the turns to come. This, roughly speaking, represented a chronological sequence during the learning of a maze.

2. To the extent that the subject was able to disregard the immediate experiences, he tended to rely upon habit to carry him through the passages.

3. Habit appeared early in the trials, with the pencil mazes, in connection with the segments first learned, while other segments were requiring study. Complete automaticity was not reported for an entire trial with any subject.

(d) Memory: 1. Memorizing was recognized as the chief difficulty only in connection with the simple mazes; with the other mazes, the difficulty was one of analysis.

2. Experiments designed to test the ability to memorize—i.e., with intricate maze paths lacking cul-de-sacs—failed to establish correlation of ability to memorize with proficiency in learning actual mazes.

3. In addition to the difficulty of retaining knowledge just acquired, while actually traversing a maze, some of the subjects complained that the intervals between trials—in Experiment I—were too long. The reports indicated that an equal distribution of interval time is not necessarily the most efficient distribution.

(e) Illusions: 1. In practically all the mazes, relative lengths of passages, and the size of angles, were wrongly estimated. Not only were the proportions distorted, but the size of the maze as a whole was generally over-estimated. This was especially in evidence with the "Mouse-trap."

2. Illusions were not as a rule productive of bad results, inasmuch as they did not disturb the notion of the turn sequences. In one or two cases, however, a different estimation of the length of a passage from the one usually made suggested to the learner that he was astray, and errors resulted.

C. The learning method

1. A certain amount of active memorizing was necessary in

order to learn the simplest mazes, and a genuine study of maze situations was called for in the complex mazes.

2. The nature of the mental effort depended upon the complexity of the maze, not upon the volition of the learner. The learner was able to vary the temporal distribution of his effort to some extent.

3. Pure "trial and error" and "pure" reasoning, or even "ideational learning," are equally inadequate terms to characterize the leaning method.

D. The learning curves

1. The obvious features of the curves were, (a), the rapid initial descent; (b), the steeples.

2. Two factors enter into the explanation of the initial descent: First, a maze whose cul-de-sacs are intricate necessitates an elaborate expenditure of time in learning to avoid entering the cul-de-sac openings. Secondly, in any maze, the notion of the relation of exit to entrance, and the general idea of the course of the true path, acquired in the first trial, enable the subject to eliminate purely random "try-outs," and thus to center his activities.

3. Steeples are associated with the second phase of the learning, in which specific problems are attacked—these problems call for systematic exploration, etc., which temporarily prolongs the time. Steeples are also due to carelessness, over-reliance upon habit, etc.